The Clean Power Plan: Compliance Costs and Options in the South

NERC Regions in the South

(NERC=North American Electricity Reliability Corporation)

This analysis was conducted for Georgia Tech's "Future of Electric Power in the South" (FEPS) initiative.

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Research Questions

- What are the CPP compliance costs likely to be in the South vs. the nation?
- How much do these costs vary across regions in the South?
- What are the least-cost compliance options in the South vs. the nation?
- Would a regional approach to compliance have merit?
- What do our results suggest for choosing between mass- versus rate-based goals?
- What can we deduce about the potential operation of a trading system for carbon emissions credits in the South?

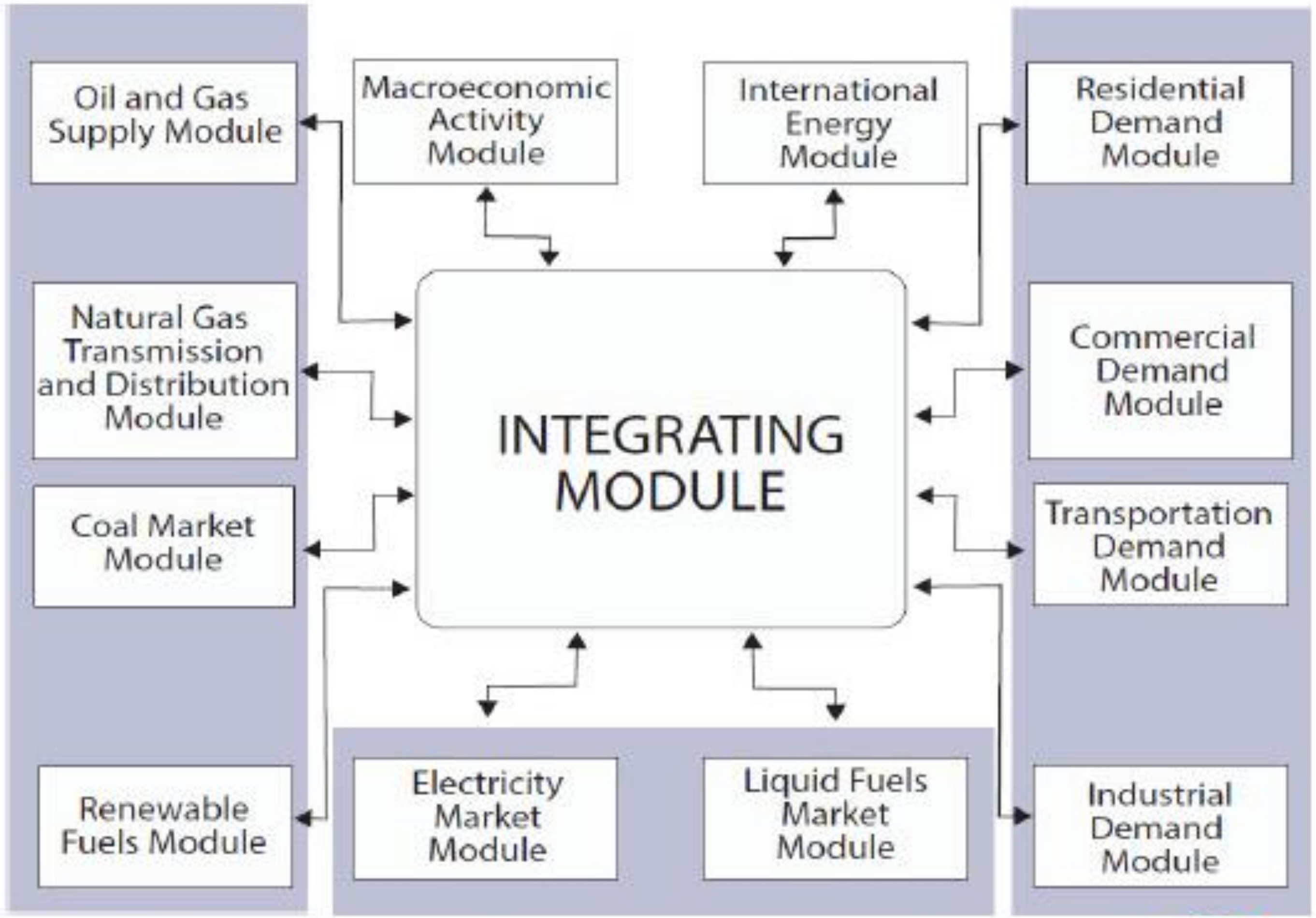
Methodology

GT-NEMS is Used to Model CPP's Compliance Costs and Options

- GT-NEMS (National Energy Modeling System) uses 22 NERC regions to forecast electricity supply and demand
- "NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to:
  - assumptions on macroeconomic and financial factors,
  - world energy markets,
  - resource availability and costs,
  - behavioral and technological choice criteria,
  - cost and performance characteristics of energy technologies, and demographics."

--Source: EIA 2009 NEMS Overview

Modules of the National Energy Modeling System



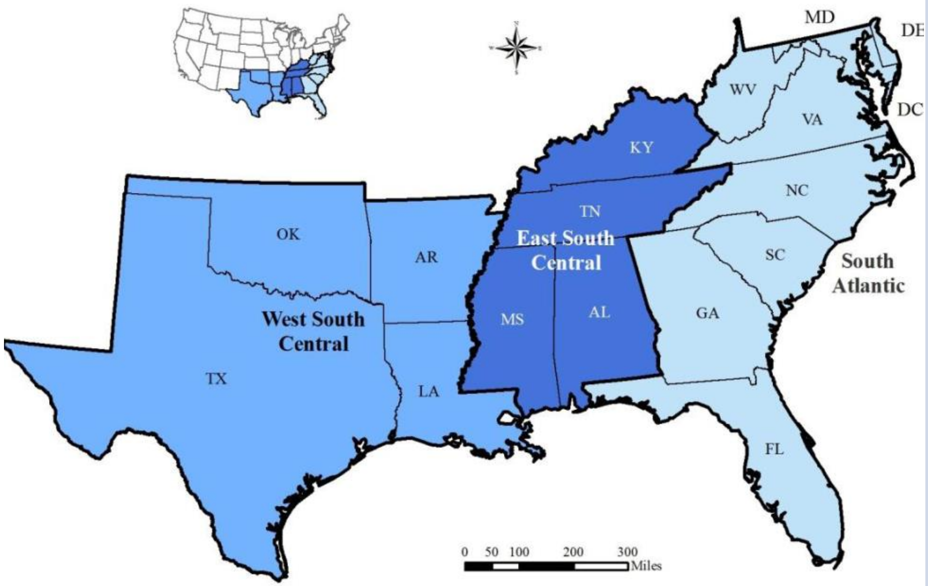
Source: U.S. Energy Information Administration. Office of Energy Analysis.

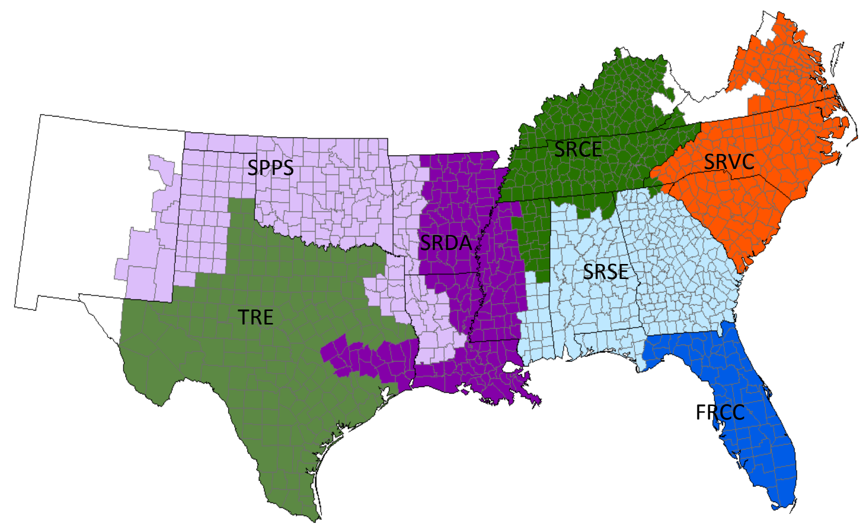
The South Census Regions for Modeling Electricity Demand

The NERC Reliability Regions for Modeling Electricity Supply

West South Central (AR, LA, OK, TX)	
East South Central (AL, KY, MS, TN)	
South Atlantic (DE, FL, GA, MD, NC, SC, VA, WV, DC)	

1. TRE (TX)
2. FRCC (FL)
12. SRDA (MS, LA, AR, TX, TN)
14. SRSE (GA, AL, MS, FL)
15. SRCE (KY, TN, GA, AL, MS, VA, NC)
16. SRVC (VA, NC, SC)
18. SPPS (OK, AR, LA, TX, NM)





(1) The Cost of Compliance: Estimated with Carbon Taxes

- We modify GT-NEMS to model various levels of carbon taxation starting in 2020 and applied only to the electric power sector.
  - Three levels of taxation are studied: $10, $20, and $30/metric tons of CO_2
  - In 2012 dollars
  - Applied in 2020 and operation through 2040
- The tax level needed to achieve a mass-based goal is one way to estimate compliance cost.
- NEMS operates with foresight, so changes in response to the carbon tax begin earlier than 2020.

(2) We have Also Specified A Solar Low-Cost Model

- LBNL's tracking of solar PV prices* was used to assess solar PV equipment costs in the NEMS Reference Case.
- We use EIA's low-cost renewable side case that assumes 20% lower equipment costs for residential and commercial solar PV compared with the reference case, which is in strong accord with LBNL's projections.
- We reduce NEMS' Reference case costs for utility-scale systems by 36% to reflect LBNL's projections because NEMS estimates are higher.
- These cost reductions are assumed to begin in 2014.

* Source: Barbose et al. (2014) "Tracking the Sun VII: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998-2013, Lawrence Berkeley National Laboratory

(3) An "Ambitious" Integrated High-Efficiency Case is also Modeled

- We employ the assumptions of EIA's High Demand Technology Side Case
  - ✓ Advanced equipment is available earlier, at lower costs, and/or at higher efficiencies
  - ✓ Stricter building codes…
- Stronger appliance and equipment standards
- Lower costs and extended tax credits for industrial CHP
- Increased energy efficiency in five manufacturing sectors
- These changes are introduced throughout the planning period, some beginning in 2014, others later.

Note: For more information: http://cepl.gatech.edu/drupal/node/88

(4) Mass- and Rate-based Goals are Estimated for 7 NERC Regions

- Plant-based CO_2 emissions data for 2012 are used to weight the state 2030 goals of the Clean Power Plan.
- Two proportioning methods were examined.

1) NEMS EMMDB to deliver state-by-state emissions from existing power plants.

2) Plant generation data from EIA's PLTF-860 survey, which is also embedded in NEMS, to deliver fossil fuel generations by state and by NERC region. Then, we multiplied the generations by CO_2 coefficients for coal, NG, and biomass generation.

- The first method was selected because it produces the lowest error when comparing 2012 CO_2 emissions to the EPA's 2012 baseline data and EIA's SEDS state data.

Overview of Clean Power Plan and CO_2 Reduction Goals

The Administration's Clean Power Plan

- On June 2, 2014, EPA proposed state-specific limits on CO_2 emissions from existing fossil fuel plants.
  - expressed in pounds of carbon dioxide per MWh
  - would collectively achieve U.S. carbon emissions reductions of 30 percent below 2005 levels by 2030
- On January 2015, EPA began the regulatory process to propose a federal plan for carbon pollution reduction from existing power plants.
- EPA is expected to publish the final rule in mid-2015.
  - Clean Power Plan for existing power plants
  - Carbon Pollution Standards for new, modified and reconstructed power plants
- States will have until June 30, 2016 to submit their action plans but can request extensions until June 2017 for individual plans, or until June 2018 for multistate plans.

(Source: EPA Fact Sheet, http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-carbon-pollution-standards-key-dates)

Mass-Based CO_2 Goals

- EPA published mass-based CO_2 goals for states in October 2014.
- These goals are not required emissions limits.
- EPA published two types of mass-based goals:
  - Based on historical emissions from existing sources; and
  - Based on existing sources *and* projected emissions that would result from demand growth that is reflected in generation at both existing and new sources.
  - We use the latter in our modeling

Source: EPA Fact Sheet, http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-technical-support-document#print

How the Rate-Based Goals Are Calculated

How the rate-based goals were developed by EPA:

CO_2 emissions – 1 Heat rate improvement – Re-dispatch

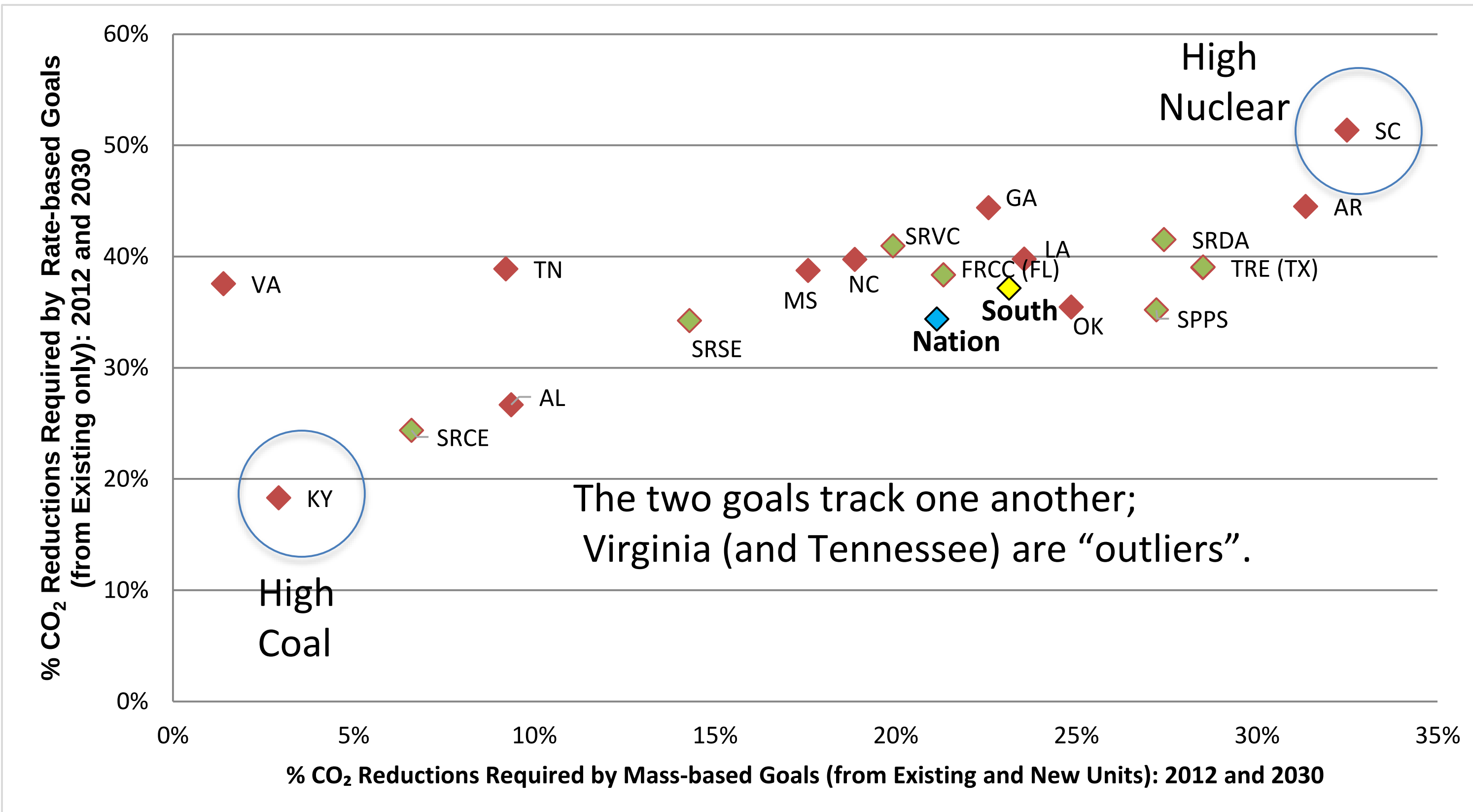
MWh Generation + 3a Nuclear + 3b Renewables + 4 Energy Efficiency

How the rate-based goals are calculated in our scenarios:

<u>Pounds of CO_2 emitted from existing sources</u>

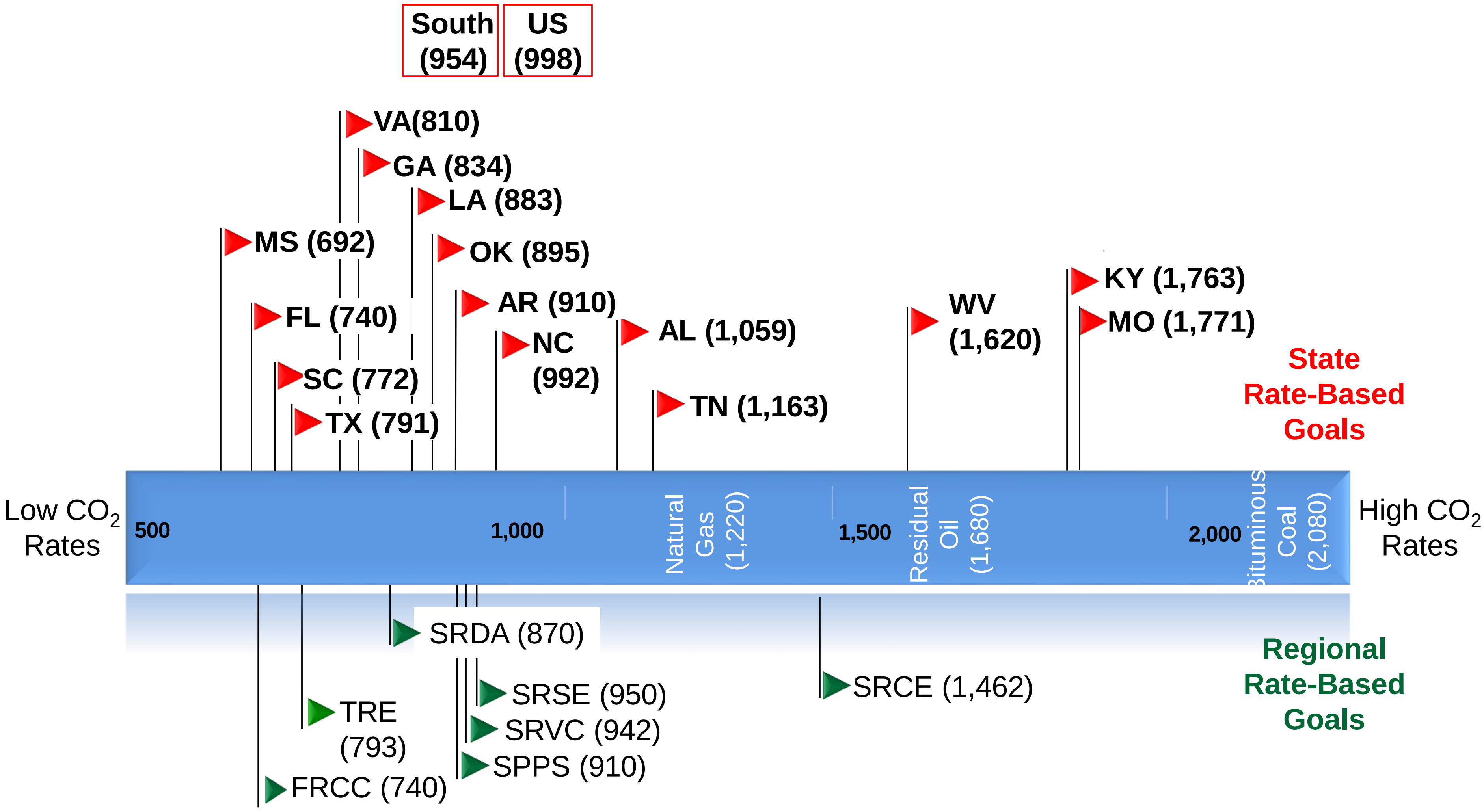
MWh of electricity generated from existing sources

Comparison of Mass- and Rate-Based CO_2 Reduction Goals



Sources: 2012 Emissions - EPA State CO2 Emissions, http://epa.gov/statelocalclimate; 2030 Goals - EPA Fact Sheet, http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-technical-support-document#print

CO_2 Rate-Based Goals and Carbon Intensity of Fuels (Lbs-CO_2/MWh)

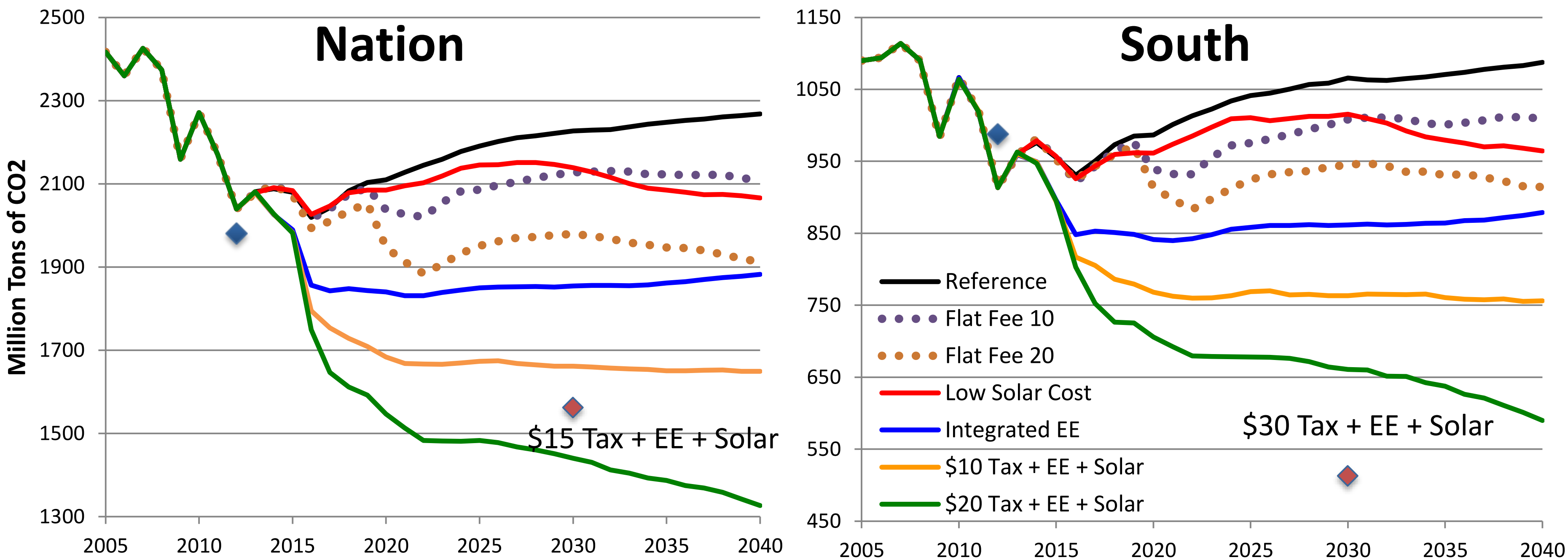


Source of carbon intensity for specific fuels is http://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11

Regional Results

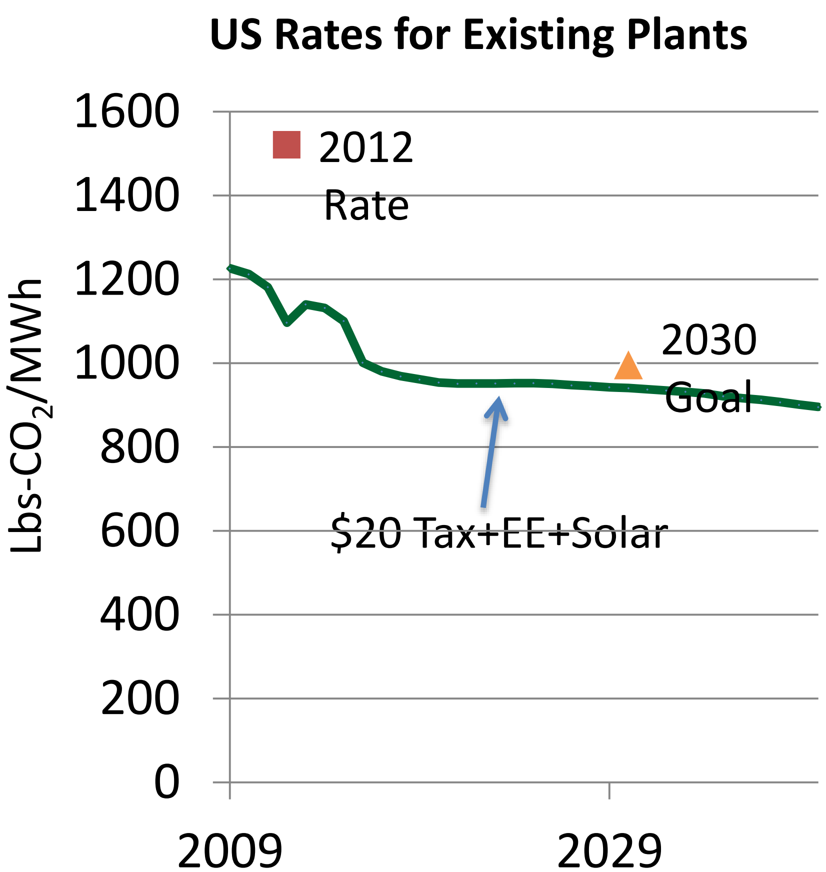
CO_2 Reduction Compliance Costs Appear to be Higher in the South

- National CO_2 reduction goals could be met with a $20 Tax + EE + Solar scenario.
- This $20 Tax + EE + Solar approach is not sufficient to meet the average mass goal in the South.



= Mass-based goal for existing affected and new sources = 5-Year Average (2010-14)

The South almost Meets its Rate-Based Goal in 2030 with $20 Tax+EE+Solar



Source of CO_2 rates in 2012: Synapse, 2014. 111(d): Next Steps for States, Webinar.

Mass-Based Goals Appear to be More Difficult to Meet

<table>
<tr><th colspan="2" rowspan="2">Performance with Respect to CPP Goals for 2030 Based on the $20 Tax+EE+Solar Scenario</th><th colspan="3">Mass-Based Goals (Existing & New Units)</th></tr>
<tr><th>Region Falls Short</th><th>Region Meets</th><th>Region Exceeds</th></tr>
<tr><td rowspan="3">Rate-Based Goals (Existing Units Only)</td><td>Exceeds</td><td>SRCE, SRVC</td><td></td><td></td></tr>
<tr><td>Meets</td><td>“The South”
SRSE,
SRVC, SRDA</td><td></td><td>“The Nation”</td></tr>
<tr><td>Falls Short</td><td>ERCT</td><td></td><td>FRCC, SPPS</td></tr>
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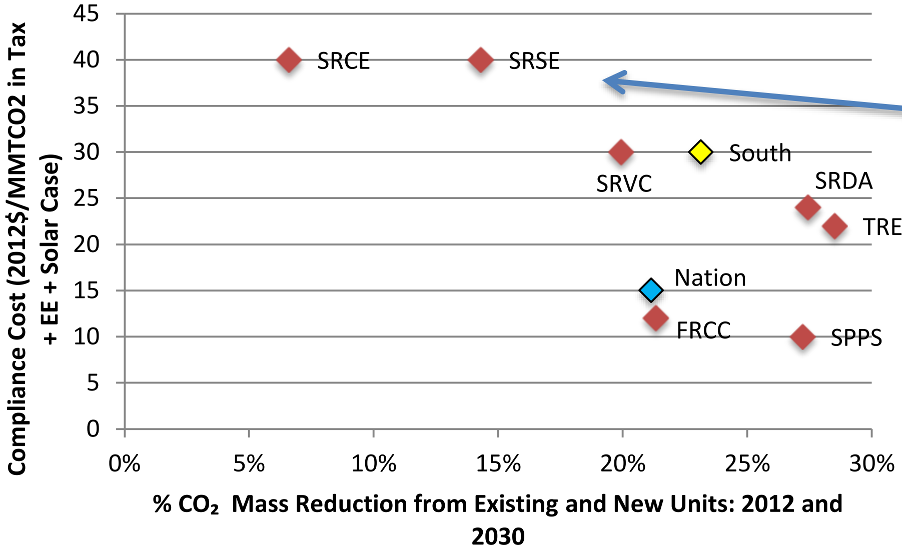
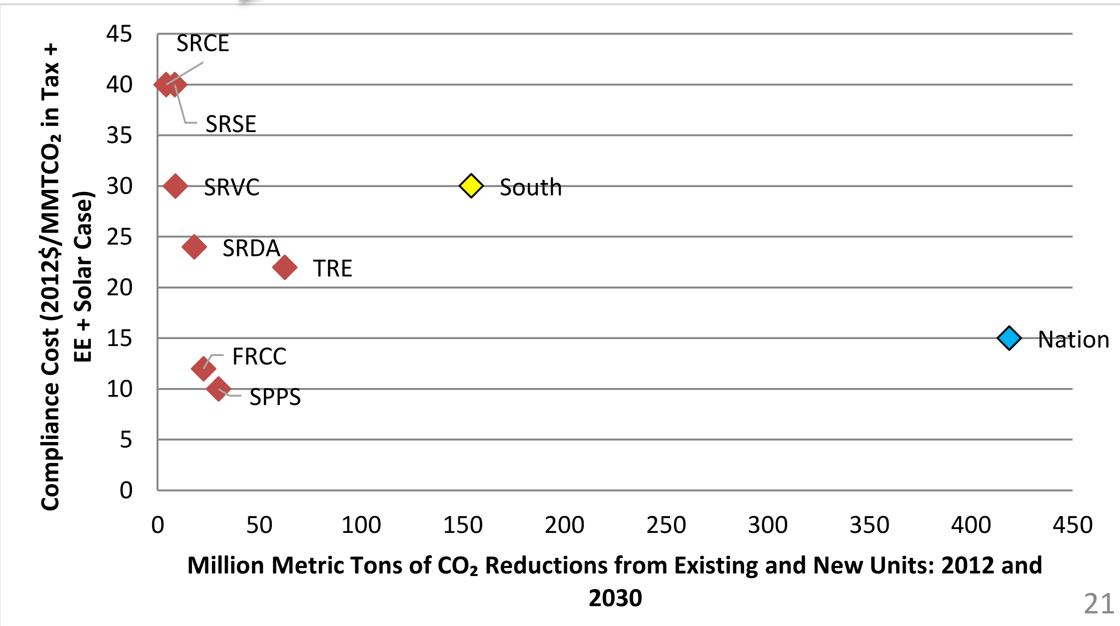
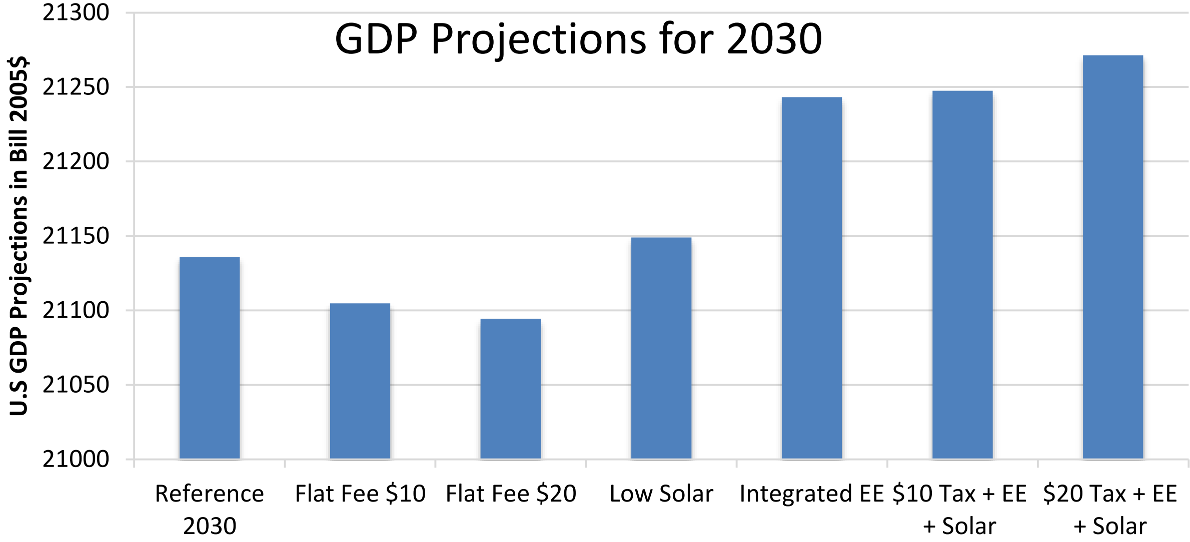
Compliance Costs are Heterogeneous

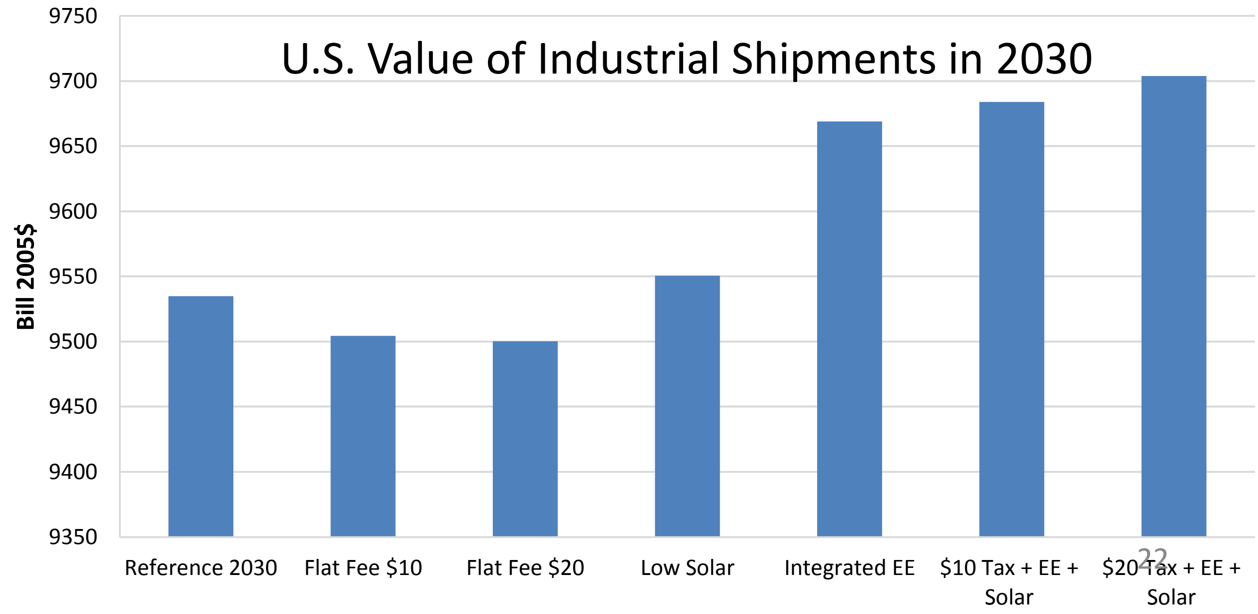


Highest compliance costs are associated with lowest CO_2 reduction goals

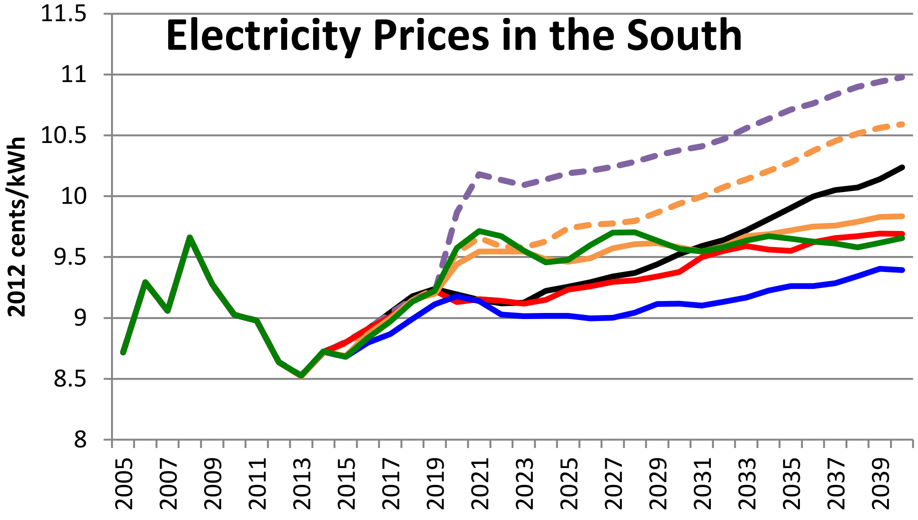


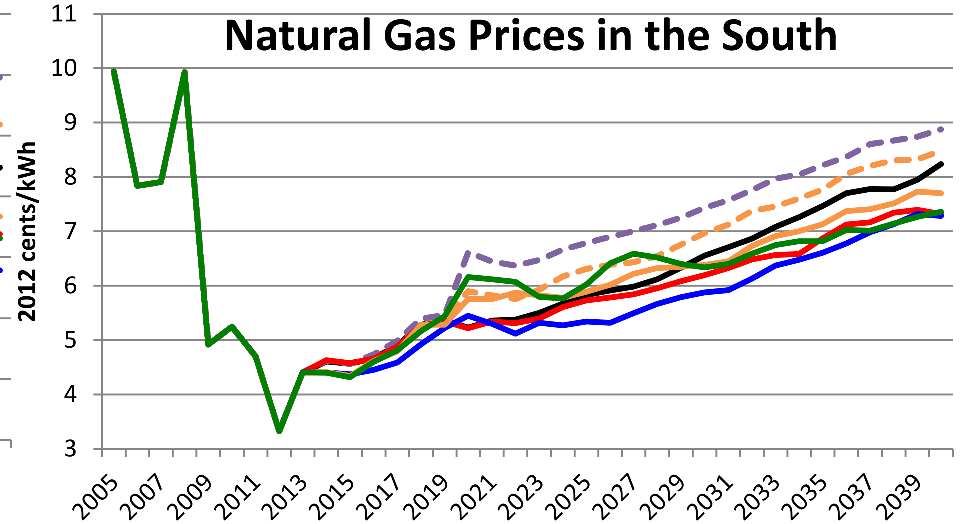
GDP: Lower with Carbon Tax, But Grows More Rapidly with the EE and Low-Cost Solar





Electricity price escalation with Tax is moderated by EE and Low-cost Solar





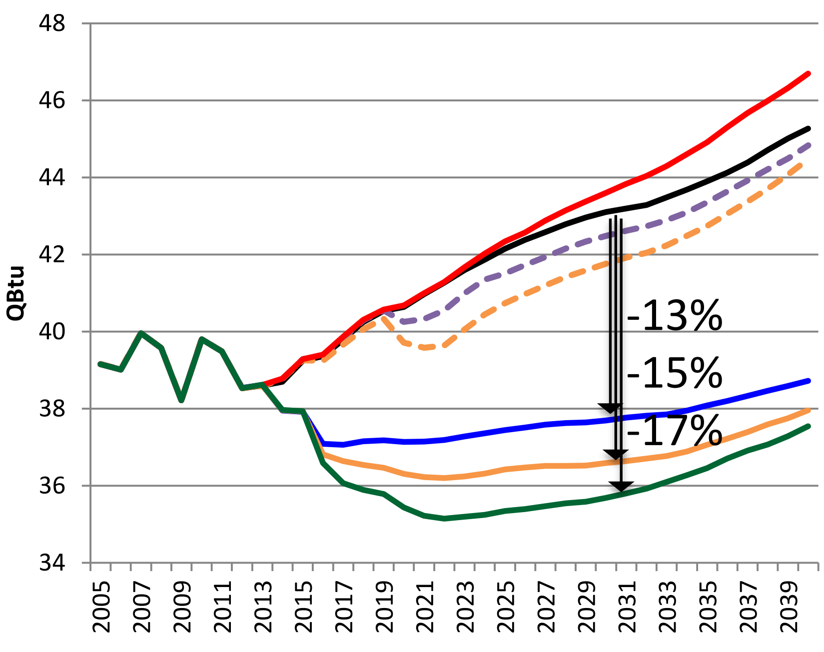
	Electricity Prices (2012 cents/kWh)		Natural Gas Prices (2012 $/MMBtu)	
	U.S.	South Average	U.S.	South Average
Reference 2012	9.84	8.64	5.38	3.32
Reference 2030	**10.48**	**9.52**	**8.51**	**6.55**
Flat Fee $10	10.86	9.94	8.63	6.97
Flat Fee $20	11.29	10.38	8.75	7.43
Low Solar	10.32	9.38	8.27	6.20
Integrated EE	9.92	9.12	8.01	5.87
$10 Tax + EE + Solar	10.35	9.58	8.15	6.38
$20 Tax + EE + Solar	10.76	9.57	8.23	6.34

Red: Higher price compared to the reference case in 2030; Green: Lower price compared to the reference case in 2030

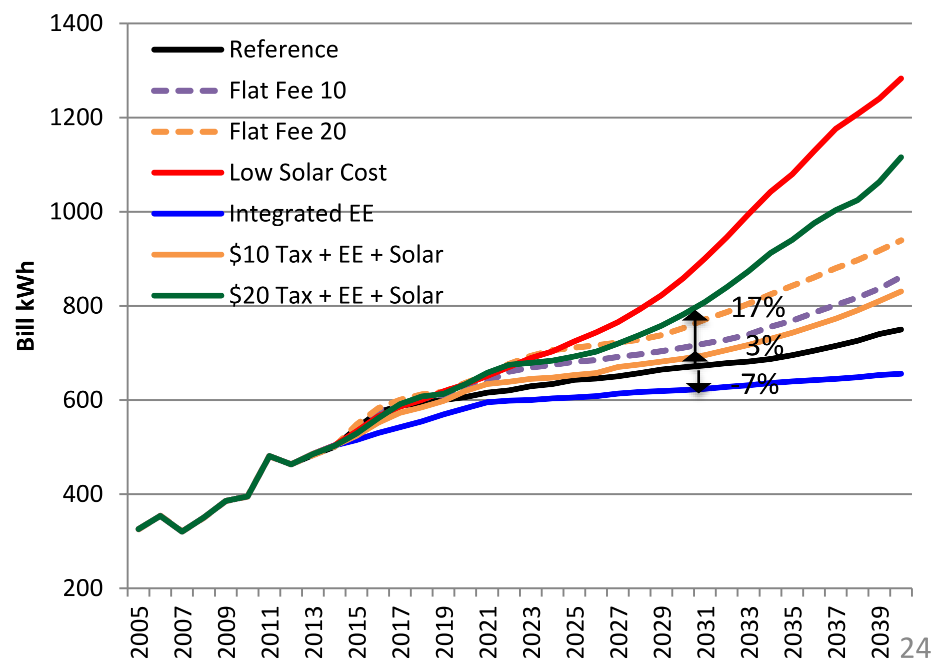
Electricity consumption declines, but EE also constrains the growth of solar

- The Tax + EE + Solar approach could reduce electricity consumption by 17% in 2030.

Total Energy Use in Electric Power Sector

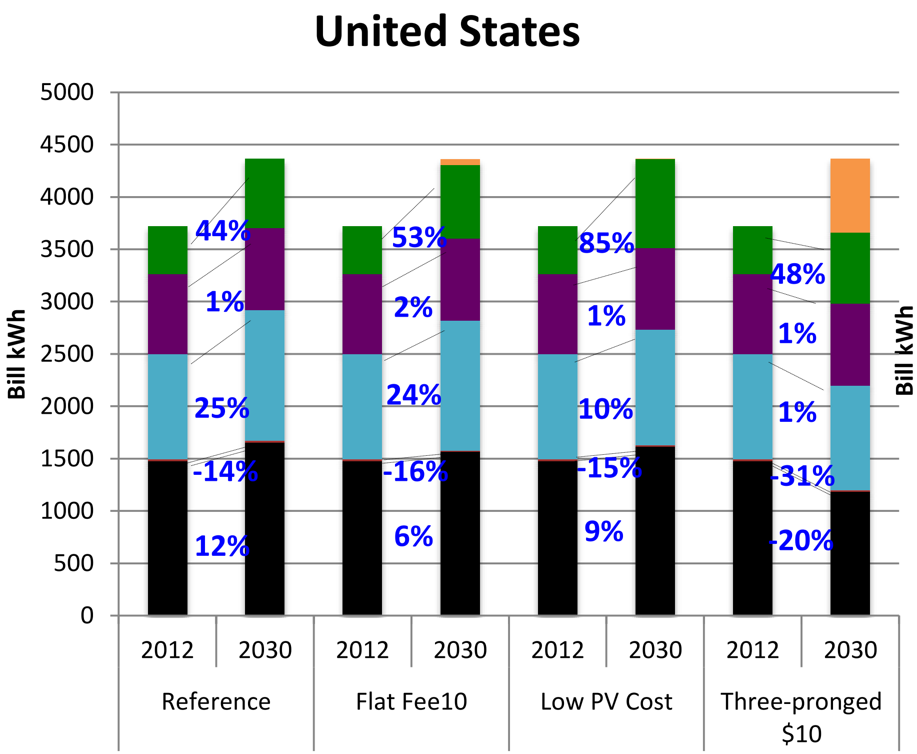


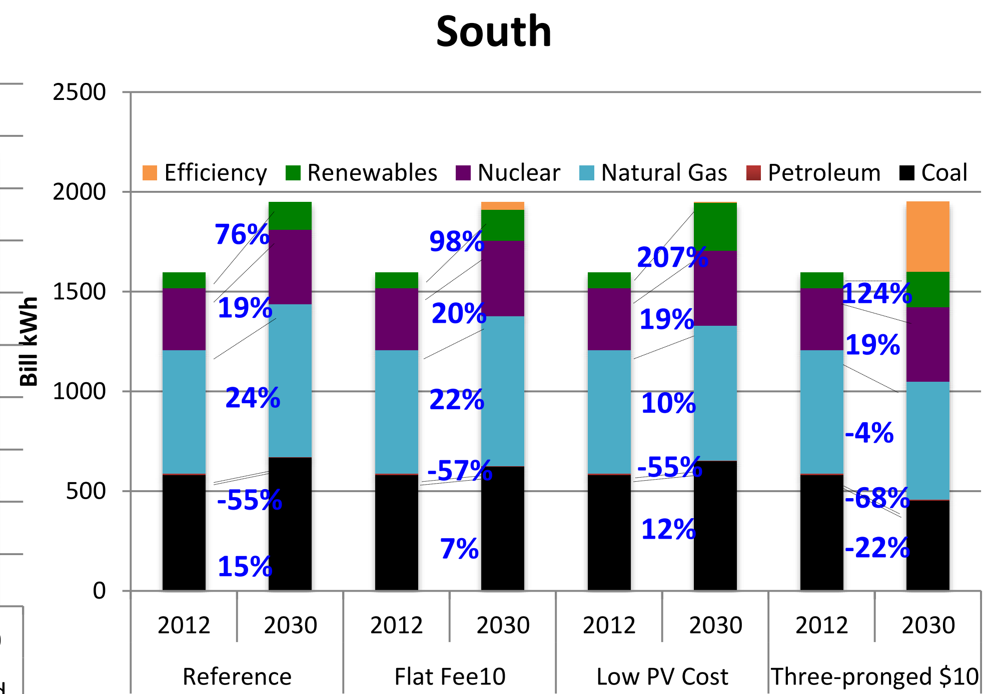
Renewable Energy Generation in Electric Power Sector



What is the Best System of Emission Reductions for the U.S. and South?

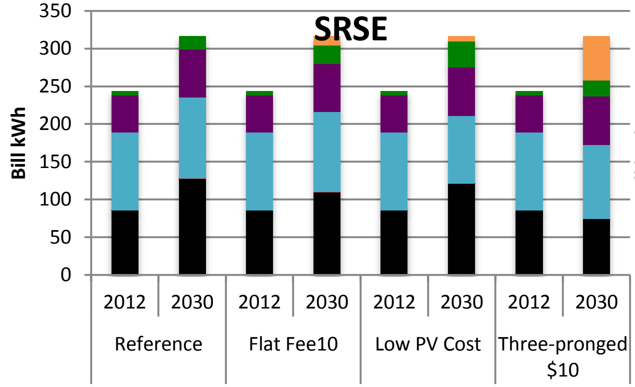
- Natural gas and renewable energy are projected to grow
- Renewable energy and nuclear would grow proportionately more in the South than the U.S.
- Some (or much) coal is retired Consumption would decline relative to the reference case

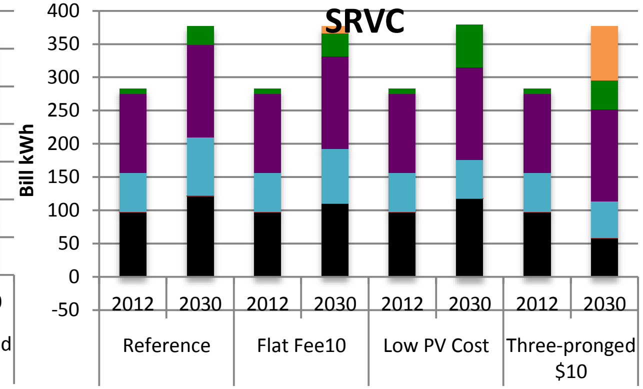




With a $10 Tax + EE + Solar:

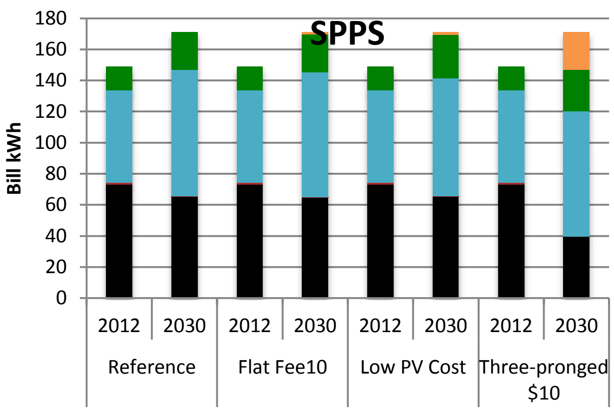
- SRCE & SRVC: Nuclear displaces coal; NG & RE grow
- SRDA & SRSE: RE displaces coal and nuclear is steady
- FRCC: Nuclear & RE displaces coal and NG.
- TRE: RE & Petroleum grow,
- SPSS: RE & NG displace coal.

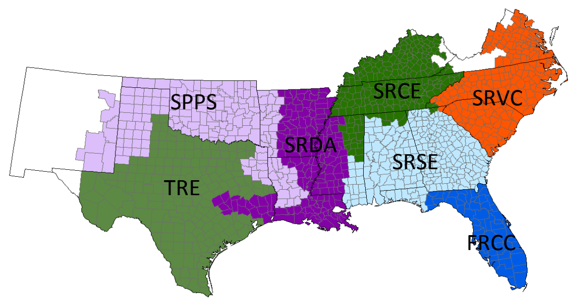


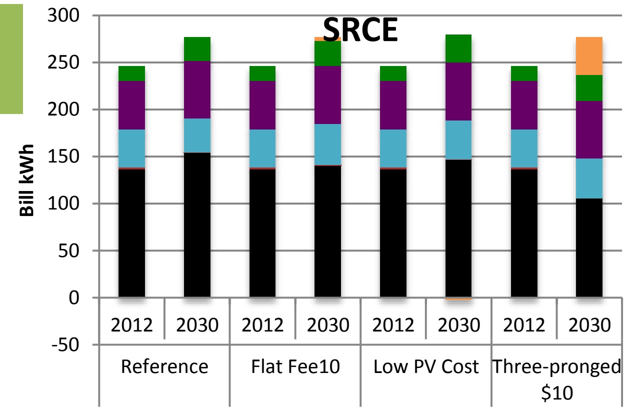


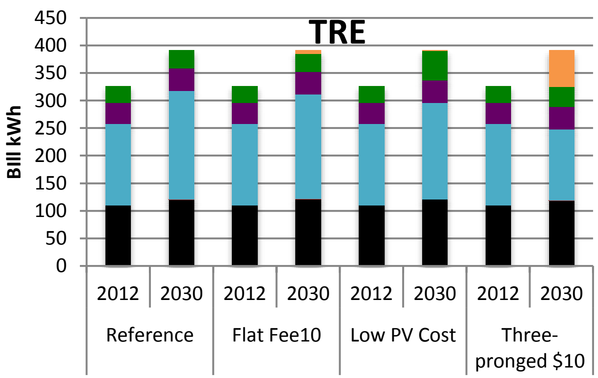
Efficiency Renewables Nuclear Natural Gas Petroleum Coal

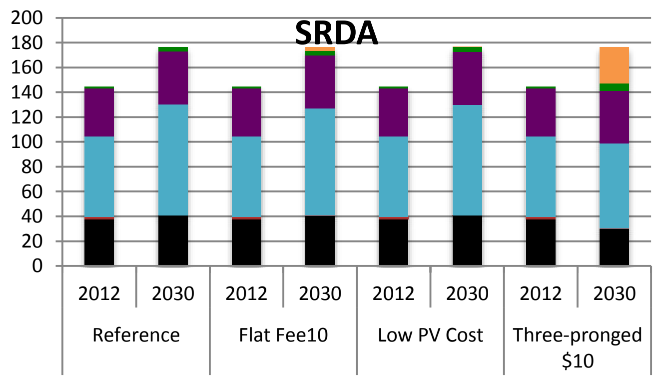
Fuel Changes by NERC Region (Bill kWh)

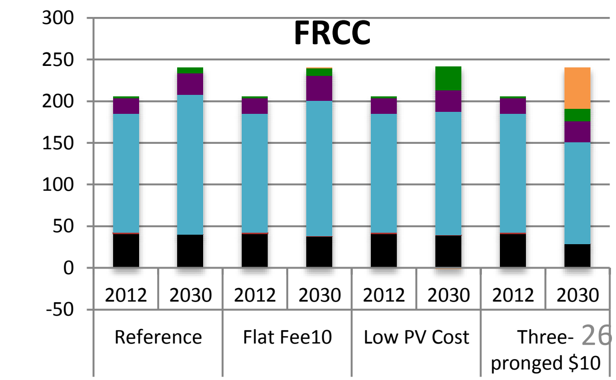






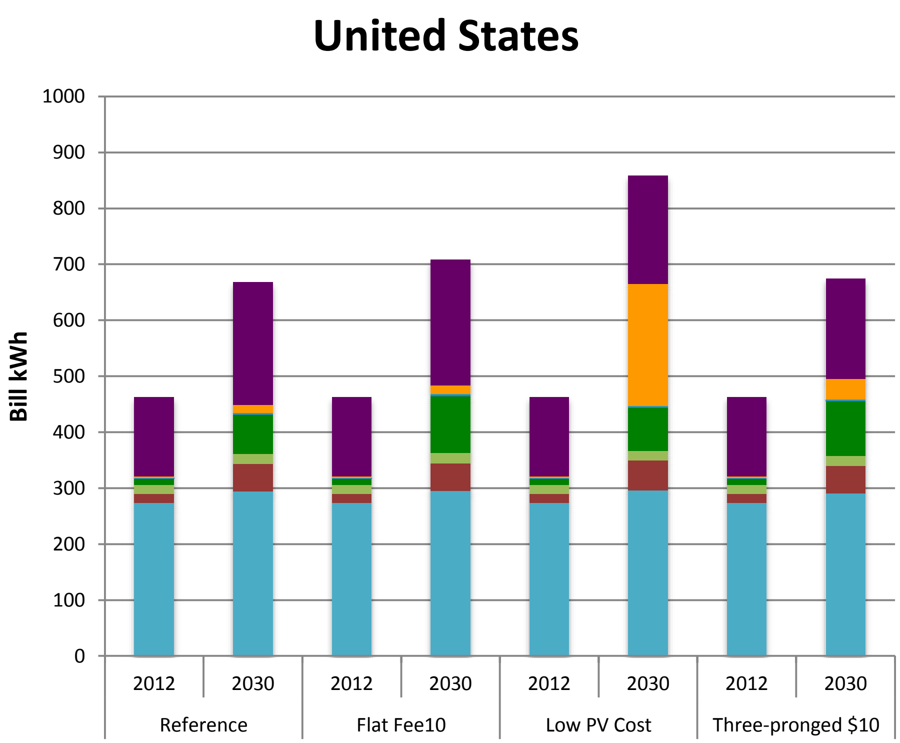


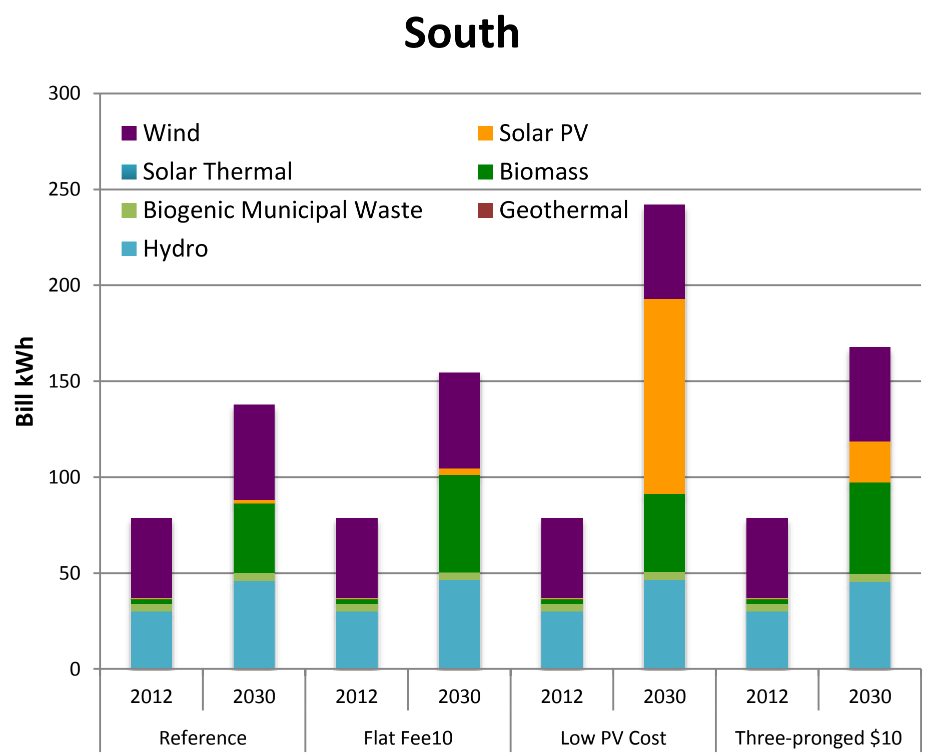




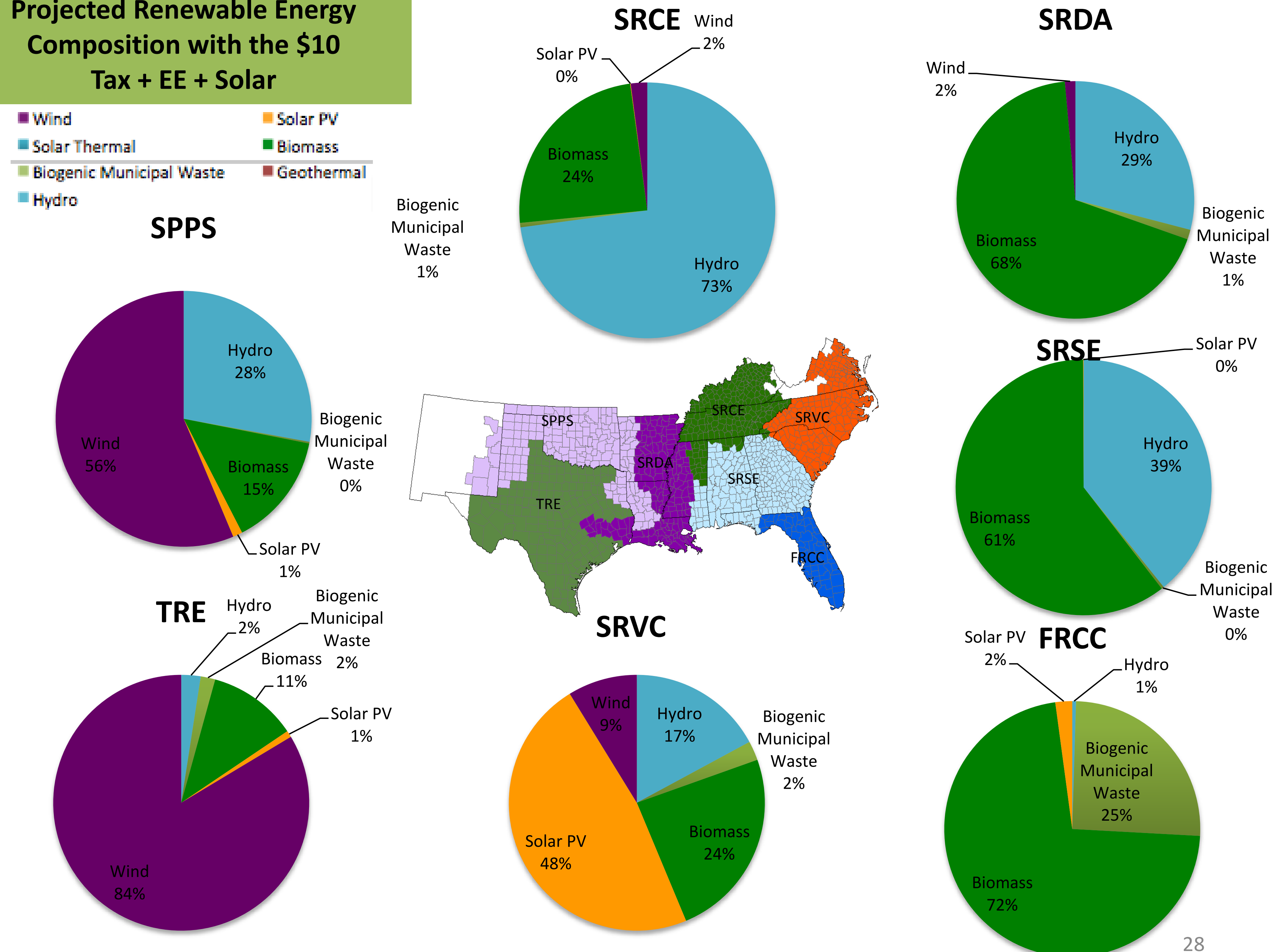
Least-Cost Renewable Energy Options Vary Across Regions

- In the nation, solar PV, biomass, geothermal, and wind grow significantly
- In the South, solar PV and biomass grow significantly (hydro slightly)





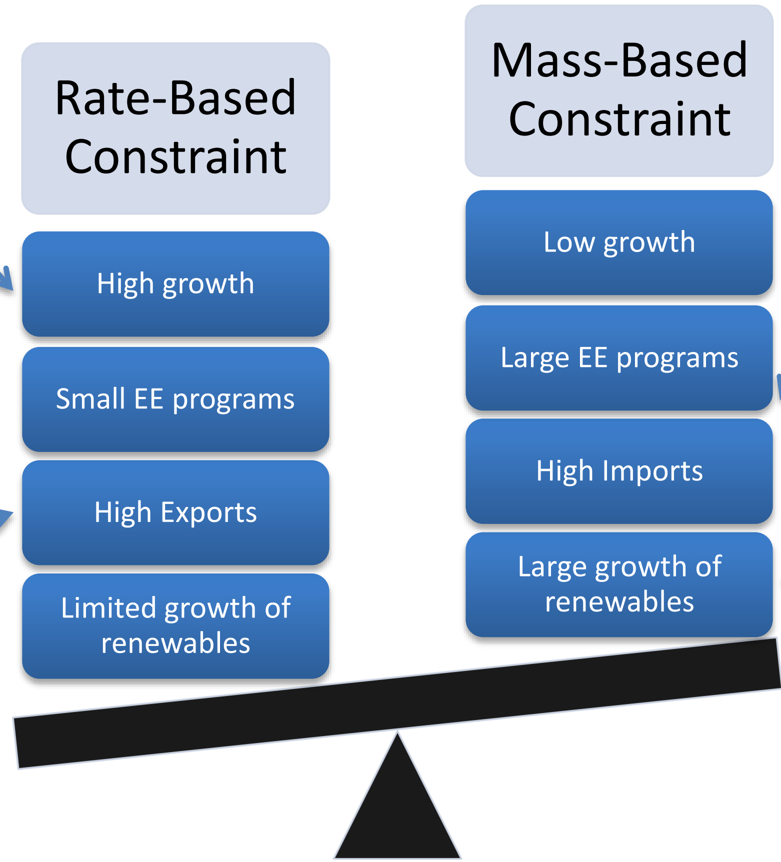
Projected Renewable Energy Composition with the $10 Tax + EE + Solar



Mass- Versus Rate-Based Goals: Some Preliminary Thoughts

High growth could lead to new natural gas capacity and hence more CO_2 emissions, which would put pressure on the state's mass goal; rates would be better.

High exports of fossil-based power would penalize the source state for associated emissions; therefore rates would be better.



Large EE programs will offset mass emissions, but may not improve rates if reductions are balanced across the portfolio; therefore mass goals would be better.

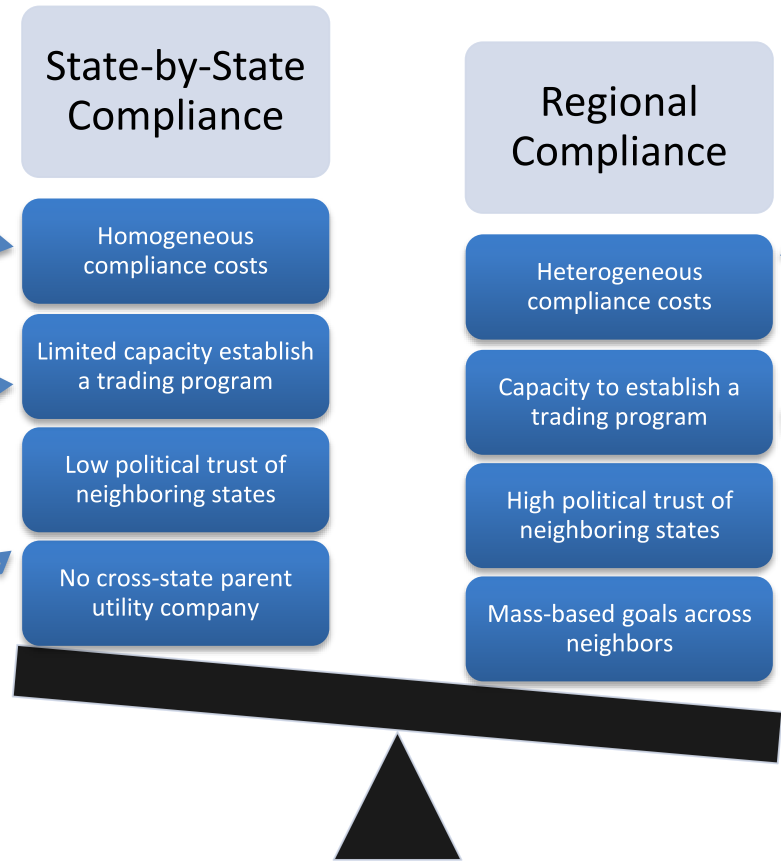
A large addition of new clean energy would likely displace fossil power and therefore reduce mass emissions.

State-by-State vs Regional Compliance Approach: Some More Preliminary Thoughts

If compliance costs are similar across states, the motivation to trade is reduced.

No excess clean capacity and little experience to expand it quickly would lead to state approach.

Trading requires some minimal level of trust; more challenging without a cross-state parent company.



Heterogeneous compliance costs mean there is an opportunity for efficiency gains through cross-state trading.

Trading systems and regional accords require legal & other capabilities, facilitated by cross-state parent company.

To date, carbon trading programs have mostly been mass-based.

For More Information*

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Back-Up Documentation

Mass-Based CO_2 Reduction Goals are Relatively High in the South

(Million Metric Tons of CO_2)	Electric Power Sector 2012 CO_2 Emissions	Existing Affected Sources			Existing Affected and New Sources		
		2030 Mass Equivalent	Reduction	% Reduction	2030 Mass Equivalent	Reduction	% Reduction
Nation	**1,981**	**1,345**	**636**	**32%**	**1,562**	**419**	**21%**
South	**857**	**555**	**302**	**35%**	**674**	**183**	**23%**
Alabama	65	**50**	**15**	**23%**	**59**	**6**	**9%**
Arkansas	34	**20**	**14**	**41%**	**24**	**11**	**31%**
Florida	106	**68**	**38**	**36%**	**83**	**23**	**21%**
Georgia	55	**32**	**23**	**42%**	**42**	**12**	**23%**
Kentucky	84	**70**	**14**	**17%**	**82**	**2**	**3%**
Louisiana	43	**27**	**16**	**38%**	**33**	**10**	**24%**
Mississippi	23	**16**	**7**	**28%**	**19**	**4**	**18%**
New Mexico	29	**10**	**18**	**64%**	**13**	**15**	**53%**
North Carolina	56	**37**	**19**	**34%**	**45**	**11**	**19%**
Oklahoma	47	**31**	**16**	**34%**	**35**	**12**	**25%**
South Carolina	33	**16**	**17**	**52%**	**22**	**10**	**33%**
Tennessee	36	**23**	**14**	**37%**	**33**	**3**	**9%**
Texas	222	**136**	**86**	**39%**	**159**	**63**	**29%**
Virginia	25	**19**	**6**	**24%**	**24**	**0**	**1%**

* Sources: 2012 Emissions - EPA State CO2 Emissions, http://epa.gov/statelocalclimate; 2030 Goals - EPA Fact Sheet, http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-technical-support-document#print)

Rate-Based CO_2 Reduction Goals

(lbs/MWh)	Electric Power Sector 2012 Rate	Existing Affected Sources		
		2030 Final Performance Goals	Difference	% Reduction
Nation	1,521	998	-523	-34%
South	1,517	954	-564	-37%
Alabama	1,444	1,059	-385	-27%
Arkansas	1,640	910	-730	-45%
Florida	1,200	740	-460	-38%
Georgia	1,500	834	-666	-44%
Kentucky	2,158	1,763	-395	-18%
Louisiana	1,466	883	-583	-40%
Mississippi	1,130	692	-438	-39%
New Mexico	1,586	1,048	-538	-34%
North Carolina	1,646	992	-654	-40%
Oklahoma	1,387	895	-492	-35%
South Carolina	1,587	772	-815	-51%
Tennessee	1,903	1,163	-740	-39%
Texas	1,298	791	-507	-39%
Virginia	1,297	810	-487	-38%

Sources: 2012 Rate from EIA data, 2030 Final Goals from EPA Proposed Rule June 2014 at http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule)

Estimated Regional Proportions of CO_2 Emissions in 2030

	Fossil Fuel Generation (NEMS PLTF-860 data)					NEMS EMMDB CO2 Emission
	Coal	NG	Biomass	Total		
	GWh				%	%
1.TRE	111,830	165,643	882	278,356		
NM	-	1	-	1	0%	0%
TX	111,830	165,642	882	278,355	100%	98%
OK					0%	2%
2. FRCC	56,825	172,884	1,466	231,175		
FL	56,825	172,884	1,466	231,175	100%	100%
12.SRDA	51,696	76,068	95	127,859		
AR	32,662	12,749	19	45,430	63%	36%
LA	12,772	38,318	76	51,165	25%	44%
MS	-	6,847	-	6,847	0%	5%
TN	6,259	5	-	6,264	12%	0%
TX	4	18,149	-	18,153	0%	15%
14. SRSE	168,970	92,602	810	262,382		
AL	55,626	35,629	374	91,629	33%	56%
FL	8,269	5,133	-	13,402	5%	0%
GA	86,831	43,554	436	130,822	51%	38%
MS	18,243	8,285	-	26,529	11%	6%
15. SRCE	199,486	43,598	125	243,209		
AL	18,168	8,687	-	26,855	9%	4%
AR						1%
GA	5,009	2,454	125	7,588	3%	0%
KY	105,543	1,498	-	107,042	53%	48%
MO						10%
MS	9,652	14,830	-	24,482	5%	9%
NC	2,232	258	-	2,490	1%	0%
OK						2%
TN	50,163	15,764	0.03	65,926	25%	26%
VA	8,719	107	-	8,826	4%	0%

Estimated Regional Proportions of CO_2 Emissions in 2030 (cont.)

	Fossil Fuel Generation (NEMS PLTF-860 data)					NEMS EMMDB CO2 Emission
	Coal	NG	Biomass	Total		
	GWh				%	%
16. SRVC	132,778	73,851	2,181	208,810		
KS	-	-	-	-	0%	0%
NC	72,702	43,535	1,493	117,730	55%	46%
SC	36,924	13,156	151	50,232	28%	29%
VA	23,152	17,159	537	40,848	17%	17%
WV						7%
18. SPPS	108,484	72,695	-	181,179		
AR	3,715	291	-	4,006	3%	2%
KS						0%
LA	8,514	9,978	-	18,493	8%	11%
MO						6%
NM	251	5,588	-	5,839	0%	1%
OK	35,607	39,069	-	74,677	33%	45%
TX	60,397	17,768	-	78,165	56%	36%
U.S.	2,206,603	1,289,852	19,298	3,519,593		
South	830,069	697,341	5,560	1,532,970		

Estimated Regional CO_2 Reduction Goals in Tons and Rates: in 2030 vs 2012

	Electric Power Sector 2012 CO2 Emissions	2030 Final Mass-based Goal, Existing and New Plants	% Reduction b/w 2012 CO2 Emission and 2030 Mass-based Goal	2012 Rate (Source: NRDC, 2014)	2030 Final Rate-based Goal	% Reduction b/w 2012 CO2 Emission and 2030 Rate-based Goal
	Million Metric Tons of CO2	Million Metric Tons of CO2	%	lbs/MWh	lbs/MWh	%
U.S.	1,980.78	1,561.91	21%	1,521	998	34%
South	667.27	512.84	23%	1,517	954	37%
1.TRE	219.09	156.64	29%	1,300	793	39%
NM	28.62	13.34	53%	1,586	1,048	34%
TX	222.12	158.78	29%	1,298	791	39%
OK	46.75	35.13	25%	1,387	895	35%
2. FRCC	105.83	83.26	21%	1,200	740	38%
FL	105.83	83.26	21%	1,200	740	38%
12.SRDA	65.58	47.59	27%	1,488	870	42%
AR	34.27	23.53	31%	1,640	910	45%
LA	42.96	32.84	24%	1,466	883	40%
MS	22.95	18.92	18%	1,130	692	39%
TN	36.34	32.99	9%	1,903	1,163	39%
TX	222.12	158.78	29%	1,298	791	39%
14. SRSE	58.96	50.53	14%	1,445	950	34%
AL	65.33	59.21	9%	1,444	1,059	27%
FL	105.83	83.26	21%	1,200	740	38%
GA	54.75	42.39	23%	1,500	834	44%
MS	22.95	18.92	18%	1,130	692	39%

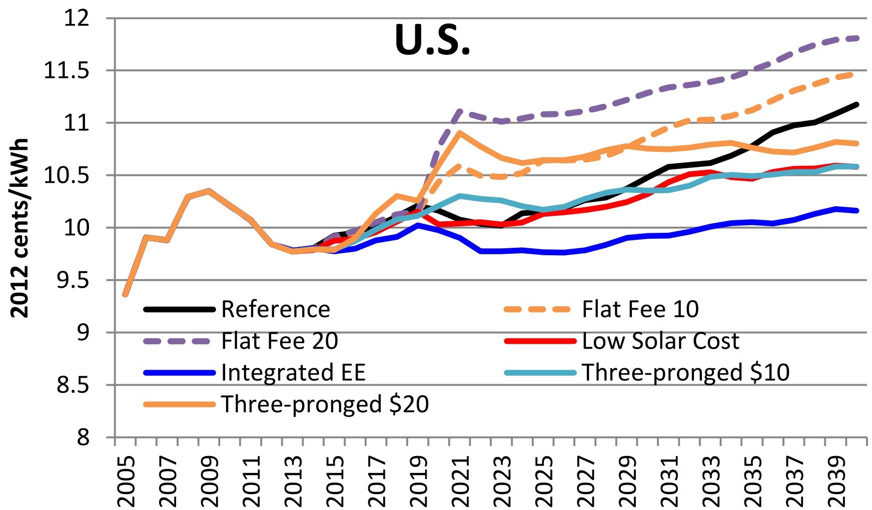
Estimated Regional CO_2 Reduction Goals in Tons and Rates: in 2030 vs 2012 (cont.)

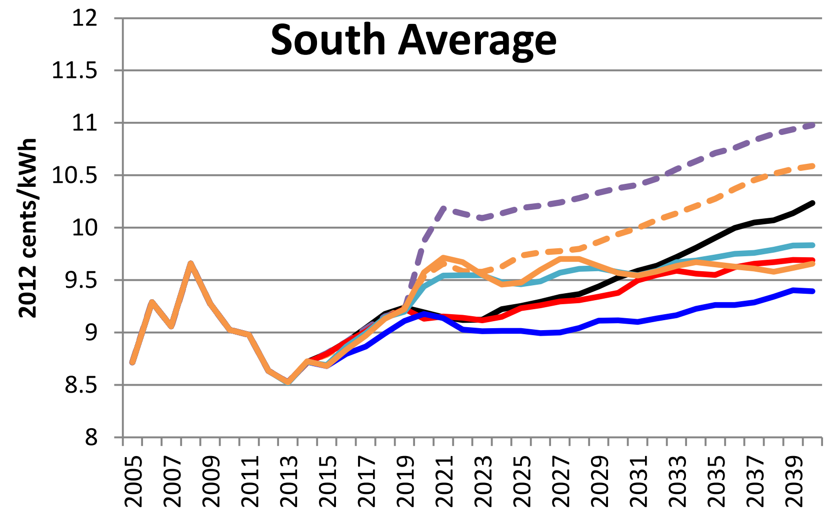
	Electric Power Sector 2012 CO2 Emissions	2030 Final Mass-based Goal, Existing and New Plants	% Reduction b/w 2012 CO2 Emission and 2030 Mass-based Goal	2012 Rate (Source: NRDC, 2014)	2030 Final Rate-based Goal	% Reduction b/w 2012 CO2 Emission and 2030 Rate-based Goal
	Million Metric Tons of CO2	Million Metric Tons of CO2	%	lbs/MWh	lbs/MWh	%
15. SRCE	63.39	59.21	7%	1,933	1,462	24%
AL	65.33	59.21	9%	1,444	1,059	27%
AR	34.27	23.53	31%	1,640	910	45%
GA	54.75	42.39	23%	1,500	834	44%
KY	84.42	81.95	3%	2,158	1,763	18%
MO	71.82	60.17	16%	1,963	1,771	10%
MS	22.95	18.92	18%	1,130	692	39%
NC	55.67	45.17	19%	1,646	992	40%
OK	46.75	35.13	25%	1,387	895	35%
TN	36.34	32.99	9%	1,903	1,163	39%
VA	24.84	24.49	1%	1,297	810	38%
16. SRVC	44.25	35.43	20%	1,596	942	41%
KS	30.11	26.70	11%	1,940	1,499	23%
NC	55.67	45.17	19%	1,646	992	40%
SC	32.61	22.01	32%	1,587	772	51%
VA	24.84	24.49	1%	1,298	810	38%
WV	65.86	54.57	17%	2,019	1,620	20%
18. SPPS	110.17	80.18	27%	1,404	910	35%
AR	34.27	23.53	31%	1,640	910	45%
KS	30.11	26.70	11%	1,940	1,499	23%
LA	42.96	32.84	24%	1,466	883	40%
MO	71.82	60.17	16%	1,963	1,771	10%
NM	28.62	13.34	53%	1,586	1,048	34%
OK	46.75	35.13	25%	1,387	895	35%

Additional Results

Electricity price escalation is moderated by EE and low-cost solar

- Rates rise but more moderately with high efficiency, in 2030

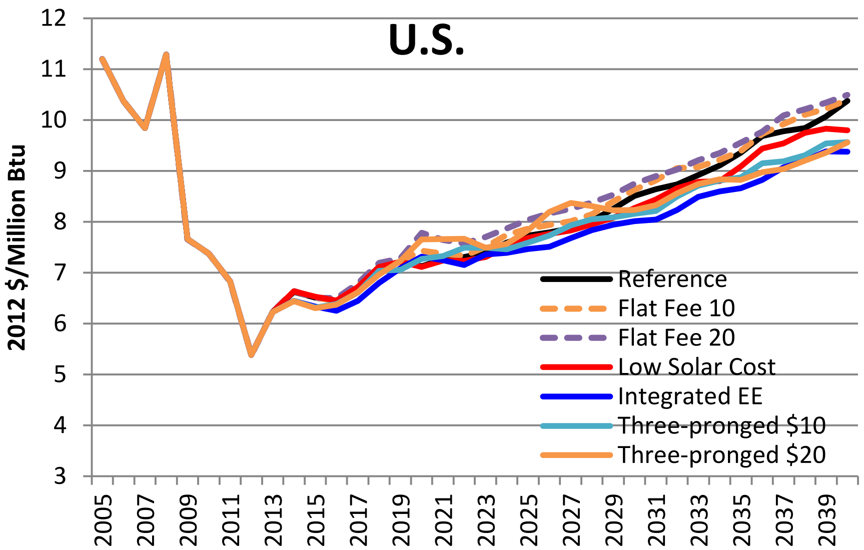


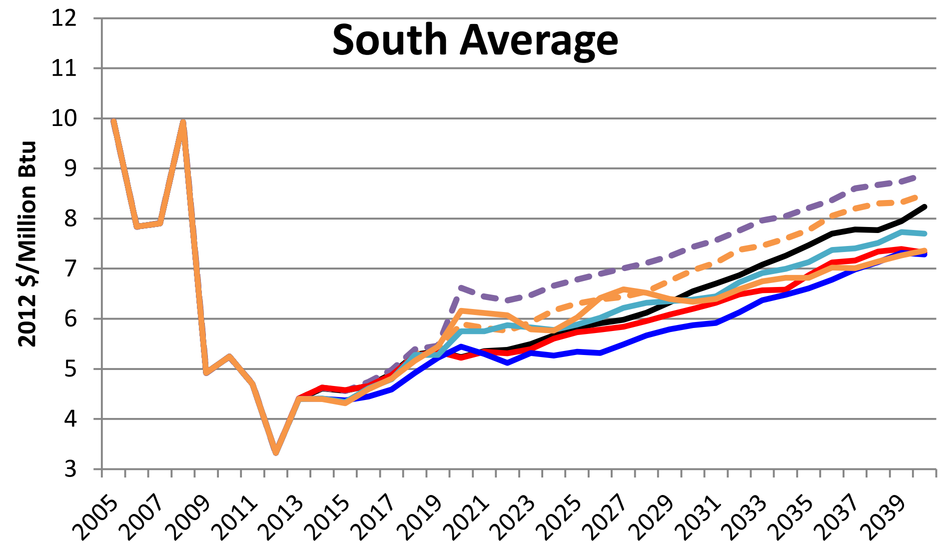


(2012 cents/kWh)	U.S.	South Average	TRE	FRCC	SRDA	SRSE	SRCE	SRVC	SPPS
Reference 2012	9.84	8.64	8.77	10.40	6.94	9.46	8.41	9.11	7.37
Reference 2030	**10.48**	**9.52**	**11.34**	**11.16**	**9.47**	**9.16**	**7.47**	**9.38**	**8.68**
Flat Fee $10	10.86	9.94	11.69	11.60	9.84	9.62	8.01	9.69	9.12
Flat Fee $20	11.29	10.38	12.17	11.99	10.26	10.07	8.48	10.01	9.66
Low Solar	10.32	9.38	10.86	10.93	9.36	9.18	7.46	9.34	8.52
Integrated EE	9.92	9.12	10.66	10.67	9.09	8.99	7.14	9.07	8.19
Tax+EE+Solar $10	10.35	9.58	11.03	11.23	9.56	9.44	7.58	9.47	8.75
Tax+EE+Solar $20	10.76	9.57	10.59	11.37	9.60	9.40	7.57	9.52	8.90

- Pink: Higher price compared to the reference case in 2030
- Green: Lower price compared to the reference case in 2030

Natural gas price escalation is also moderated by EE and low-cost solar





(2012 cents/kWh)	U.S.	South Average	TRE	FRCC	SRDA	SRSE	SRCE	SRVC	SPPS
Reference 2012	5.38	3.32	2.93	4.66	2.94	3.20	3.00	3.57	2.95
Reference 2030	**8.51**	**6.55**	**6.04**	**7.92**	**6.05**	**6.37**	**6.51**	**6.94**	**6.04**
Flat Fee $10	8.63	6.97	6.43	8.30	6.45	6.82	6.98	7.35	6.43
Flat Fee $20	8.75	7.43	6.90	8.76	6.91	7.30	7.47	7.80	6.90
Low Solar	8.27	6.20	5.72	7.56	5.73	6.05	6.12	6.47	5.72
Integrated EE	8.01	5.87	5.39	7.20	5.42	5.84	5.75	6.12	5.39
$10 Tax + EE + Solar	8.15	6.38	5.89	7.68	5.91	6.37	6.26	6.68	5.89
$20 Tax + EE + Solar	8.23	6.34	5.80	7.65	5.84	6.35	6.23	6.70	5.80

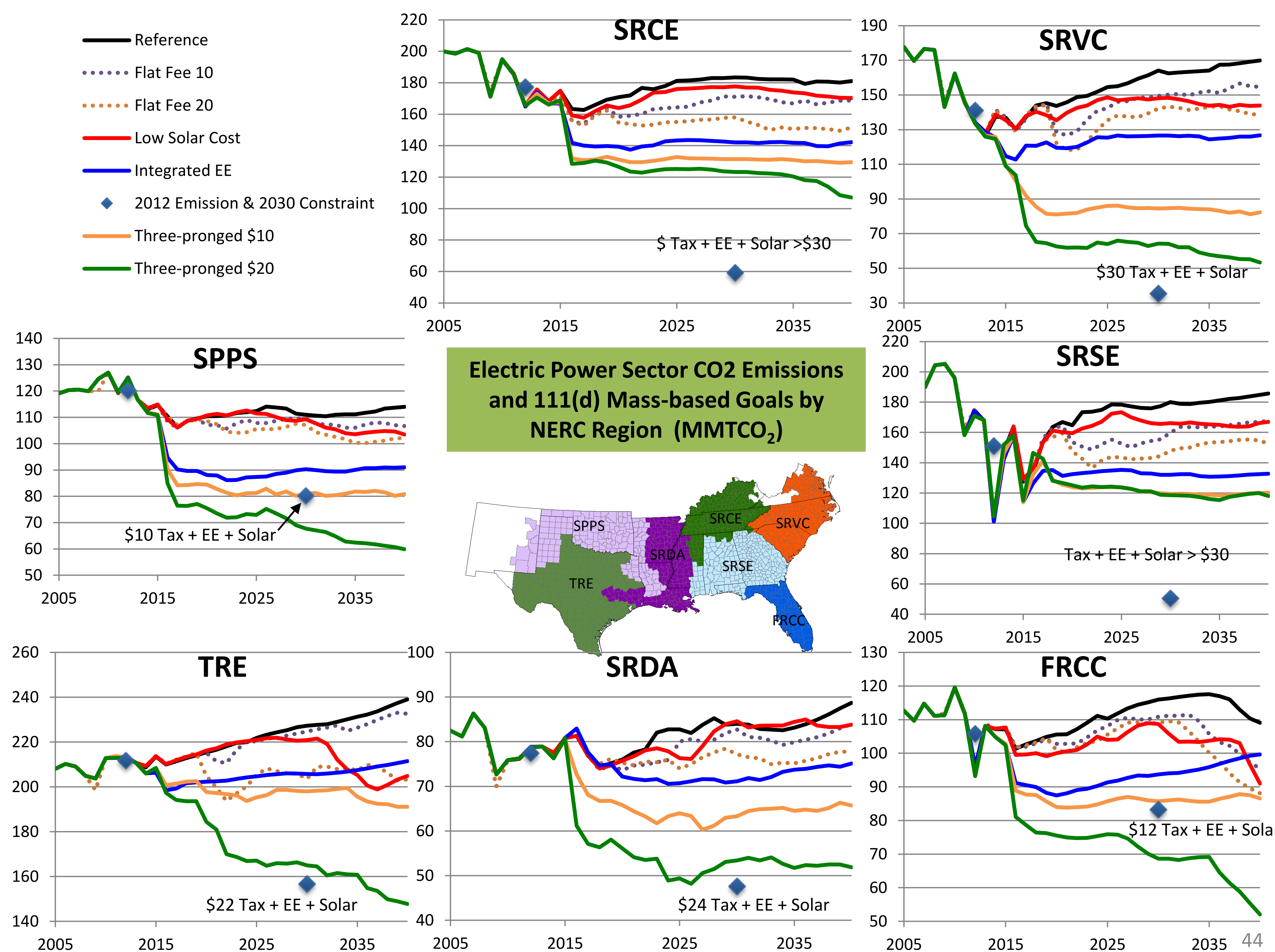
- Pink: Higher price compared to the reference case in 2030
- Green: Lower price compared to the reference case in 2030

Value of Industrial Shipment Grow in the EE and Low-Solar Scenarios

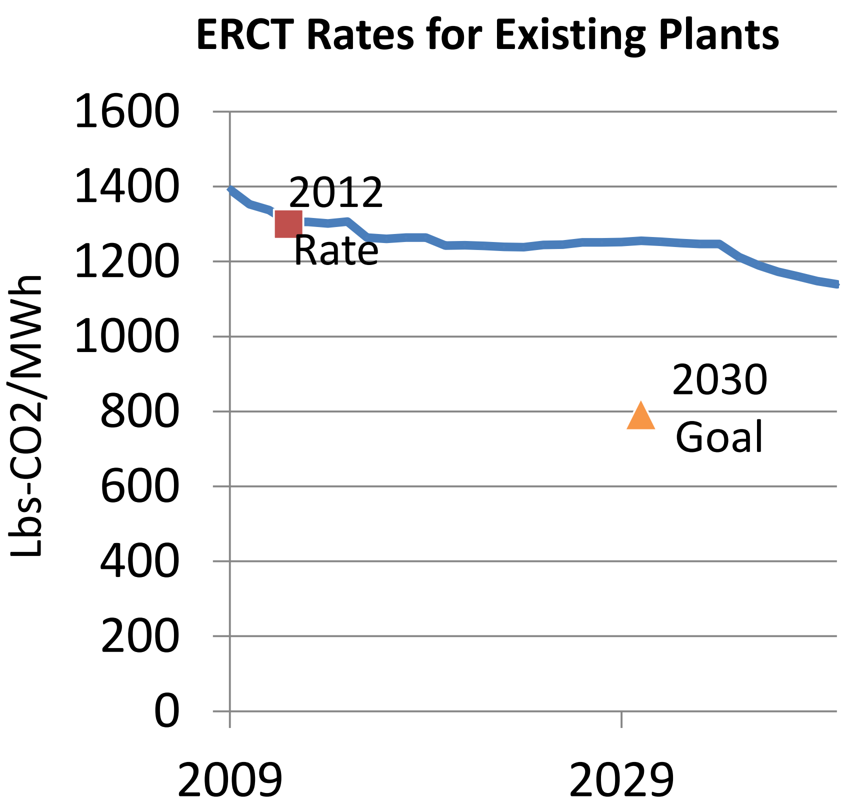
		GDP (Bill 2005$)	Value of Industrial Shipments (Bill 2005$)
U.S.	Reference 2012	13593.2	6,147.5
	Reference 2030	21135.8	9,534.8
	Flat Fee $10	21104.7	9,504.3
	Flat Fee $20	21094.4	9,500.3
	Low Solar	21149.0	9,550.6
	Integrated EE	21243.1	9,668.9
	$10 Tax + EE + Solar	21247.4	9,683.9
	$20 Tax + EE + Solar	21271.4	9,703.8
South	Reference 2012		2,403.7
	Reference 2030		3,590.7
	Flat Fee $10		3,579.7
	Flat Fee $20		3,577.4
	Low Solar		3,597.4
	Integrated EE		3,631.3
	$10 Tax + EE + Solar		3,634.7
	$20 Tax + EE + Solar		3,640.8

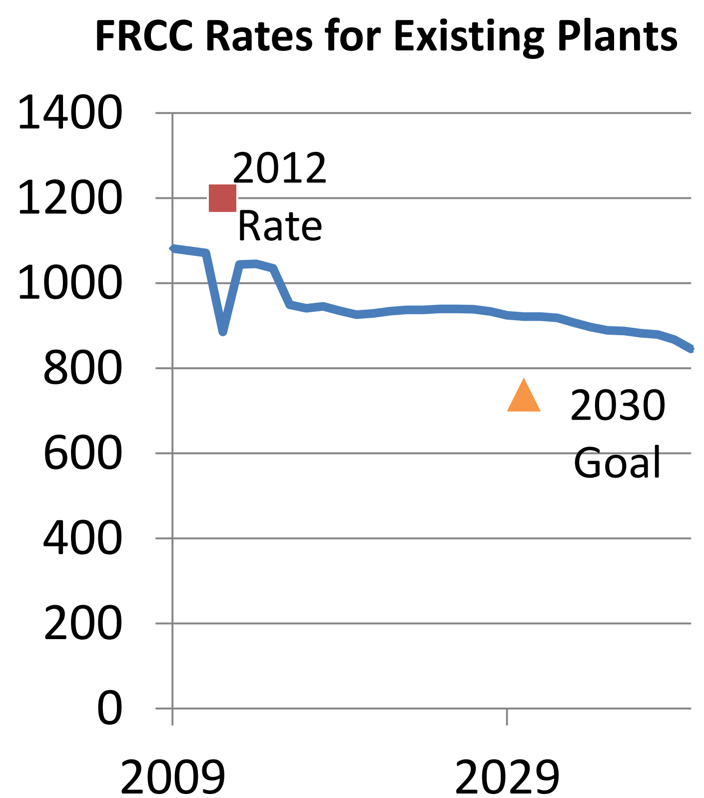
Regional Results

Electric Power Sector CO2 Emissions and 111(d) Mass-based Goals by NERC Region ($MMTCO_2$)

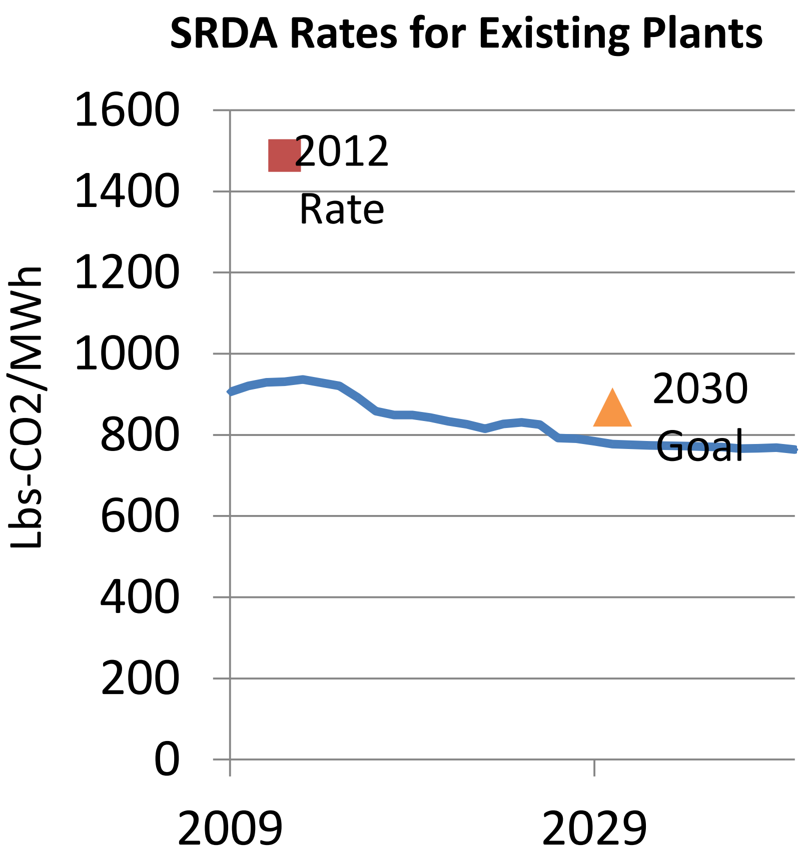


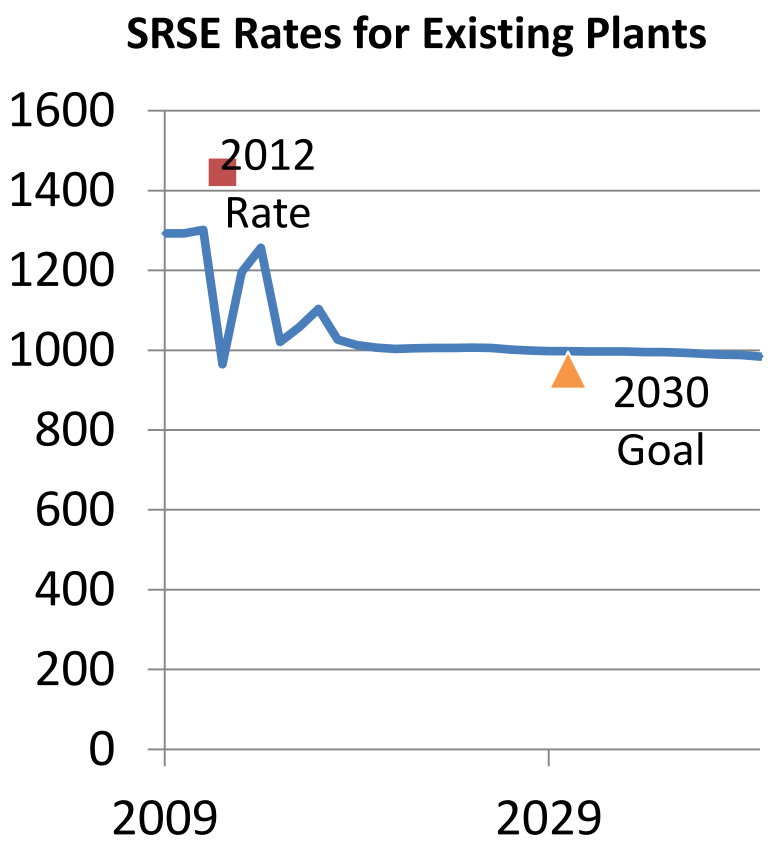
Impact of $20 Tax+EE+Solar on CO_2 Emission Rates (Existing Units)



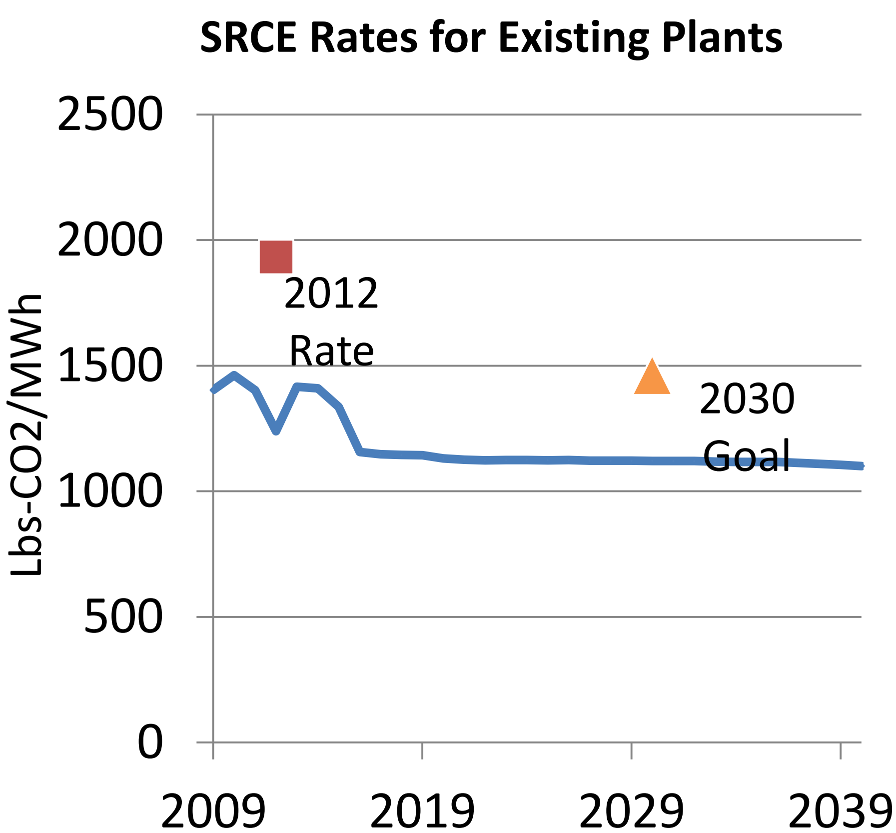


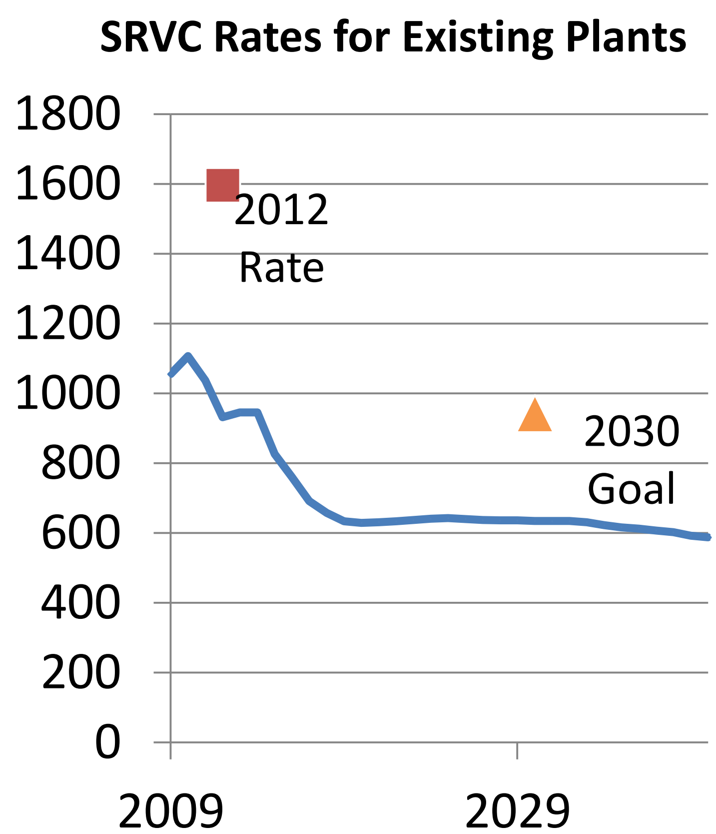
Impact of $20 Tax+EE+Solar on CO_2 Emission Rates (Existing Units)



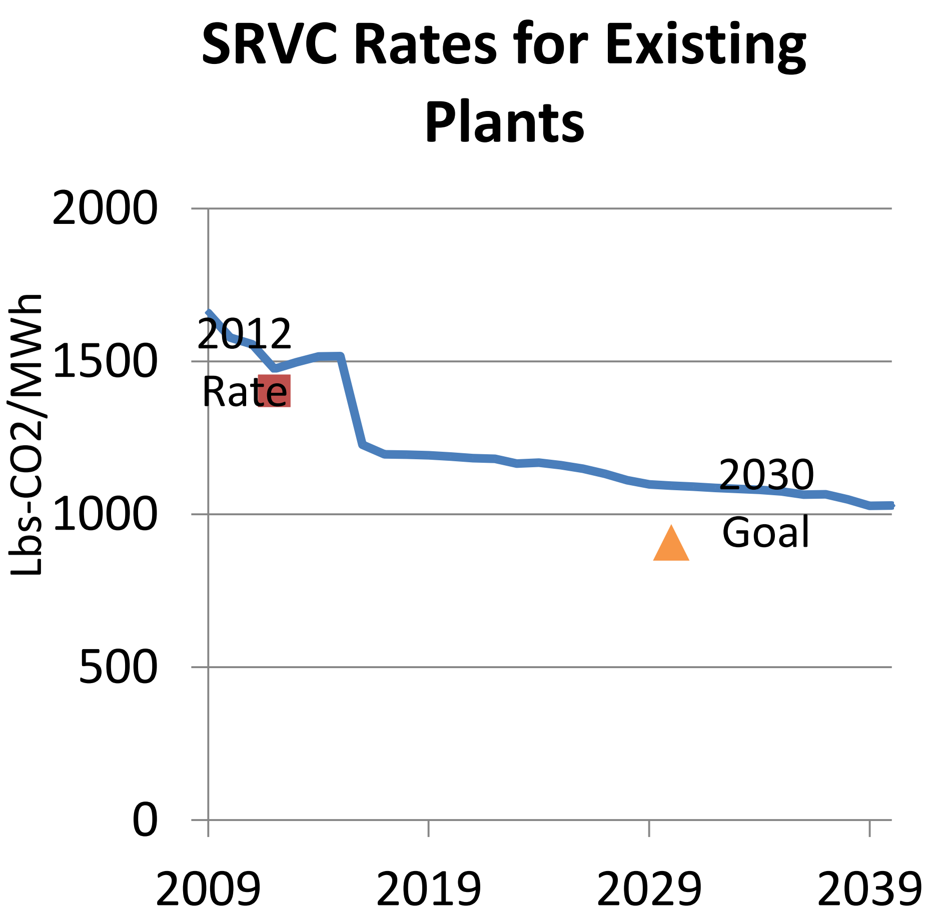


Impact of $20 Tax+EE+Solar on CO2 Emission Rates (Existing Units)





Impact of $20 Tax+EE+Solar on CO2 Emission Rates (Existing Units)



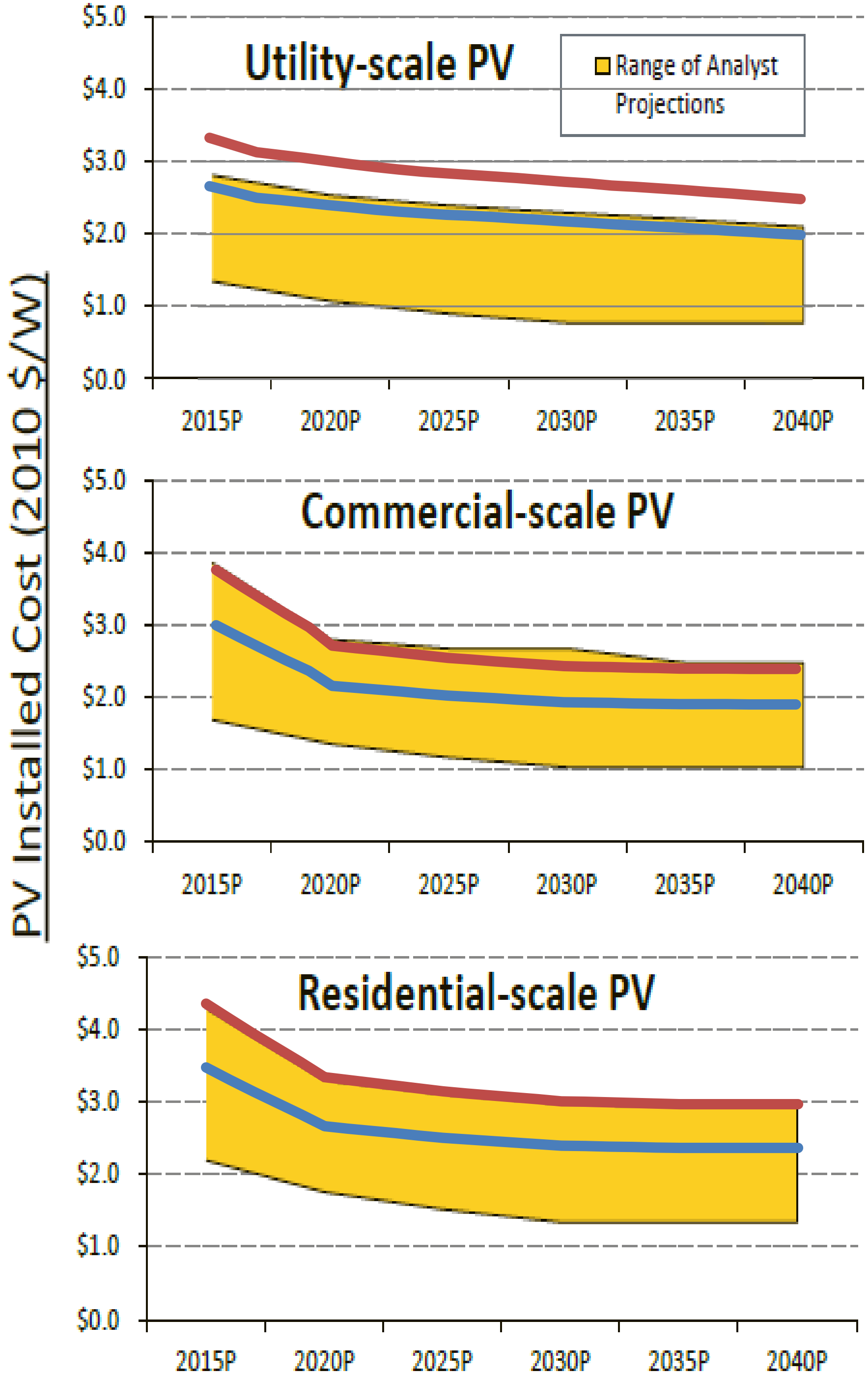
Solar Low-Cost Assumptions

Incorporating More Realistic Utility-Scale PV System Costs

Sources: Yellow area figure taken from LBNL/NREL (2014) *Tracking the Sun VII*. Sources used by LBNL and NREL are:

Bloomberg New Energy Finance, Q2 2014, "PV Market Outlook" (05/15/14); Greenpeace/EREC, "Energy Revolution," May 2014 (utility-scale only); International Energy Agency, "World Energy Outlook 2013," November 2013 (New Policy & 450 Scenarios for utility-scale & commercial-scale); U.S. Energy Information Administration, Annual Energy Outlook 2014 ER (December 2013).

In years where projection was not made, most recent projection used.



GT-NEMS' Utility-scale PV costs in both cases appear a bit high compared to long-range projections.

Compared to long-range projections, GT-NEMS' costs of solar PV for commercial and residential in the low-cost side case appear appropriate.